POWER PLANT ENGINEERING

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Narragansett Company Installs 45,000-kw. Turbo-Generator

CROSS-COMPOUND DOUBLE UNIT TYPE REACTION TURBINE WITH WORLD'S LARGEST CONDENSING UNIT PRESENT MANY INTERESTING FEATURES OF CONSTRUCTION, INSTALLATION AND OPERATION. BY J. P. RIGSBY

THE 45,000-KW. TURBO-GENERATOR unit recently put into opertation in the power station of the Narragansett Electric Light Co., at Providence, R. I., is of the cross-compound double unit type, consisting of a high and low-pressure turbine, each connected through a flexible coupling to its own generator, having a capacity of 22,500 kw., and mounted on separate bedplates supported on foundations lying parallel to each other. The generators are arranged to feed separately or together to the main bus.

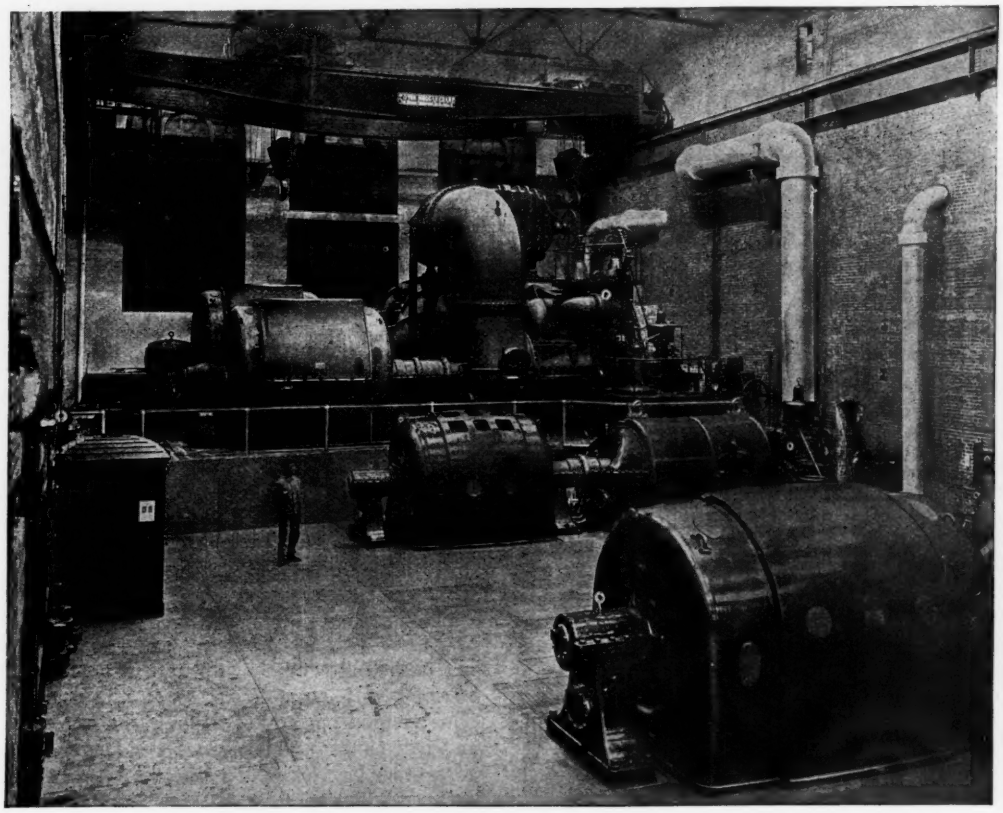


FIG. 1. RECENTLY INSTALLED 45,000-KW. TURBO-GENERATOR OF THE NARRAGANSETT ELECTRIC LIGHT CO.

This type of turbine is very successfully exemplified by the three 30,000-kw. units installed a few years ago in the 74th Street Station of the Interboro Rapid Transit Co., New York.

Steam enters the high-pressure turbine through suitable governor-controlled valves, passes through this single flow element, and out through an exhaust on the top, and is conducted by means of a receiver pipe overhead to the middle of the double flow low-pressure turbine alongside, where it divides, flowing in opposite directions through low-pressure blading, then down through the exhaust chambers into two jet condensers of the latest hurling type.

Energy given up by the steam at full load is equally

divided between the high and low-pressure turbine, the generators dividing the load in half; at lower loads a greater proportion is carried by the high-pressure element.

The unit was designed to operate with a steam pressure at the throttle of 200 lb. with 100 deg. superheat and a vacuum of 29 in. in the exhaust, while the generators have a capacity of 23,750 kv.a., 11,000 v., 3 phase, 60 cycles at 0.95 factor, the high-pressure element having a speed of 1800 r.p.m. and the low-pressure 1200 r.p.m.

There are four bearings to each unit, a flexible pin type coupling being used to connect the turbine and generator.

admitted, of course, direct to the cylinder casing instead of into nozzle chambers, as is the case with an impulse type. This presents the problem of perfecting a horizontal joint on a cylinder of considerable diameter that will be tight, and stay tight, against 200 to 300 lb. steam pressure, or any tendency to open, due to distortions from the high temperature.

The high-pressure end, or steel part of the cylinder, is composed of two steel castings, 5 ft. 10 in. inside diameter and 1¾ in. thick, while at the joint thickness gradually increases until it merges into a flange 8 in. wide, tapering to the outer edge. The bolts, 2¼ in. in diameter, are spaced about one-third of the way from the inside edge. These bolts, or studs as they really are,

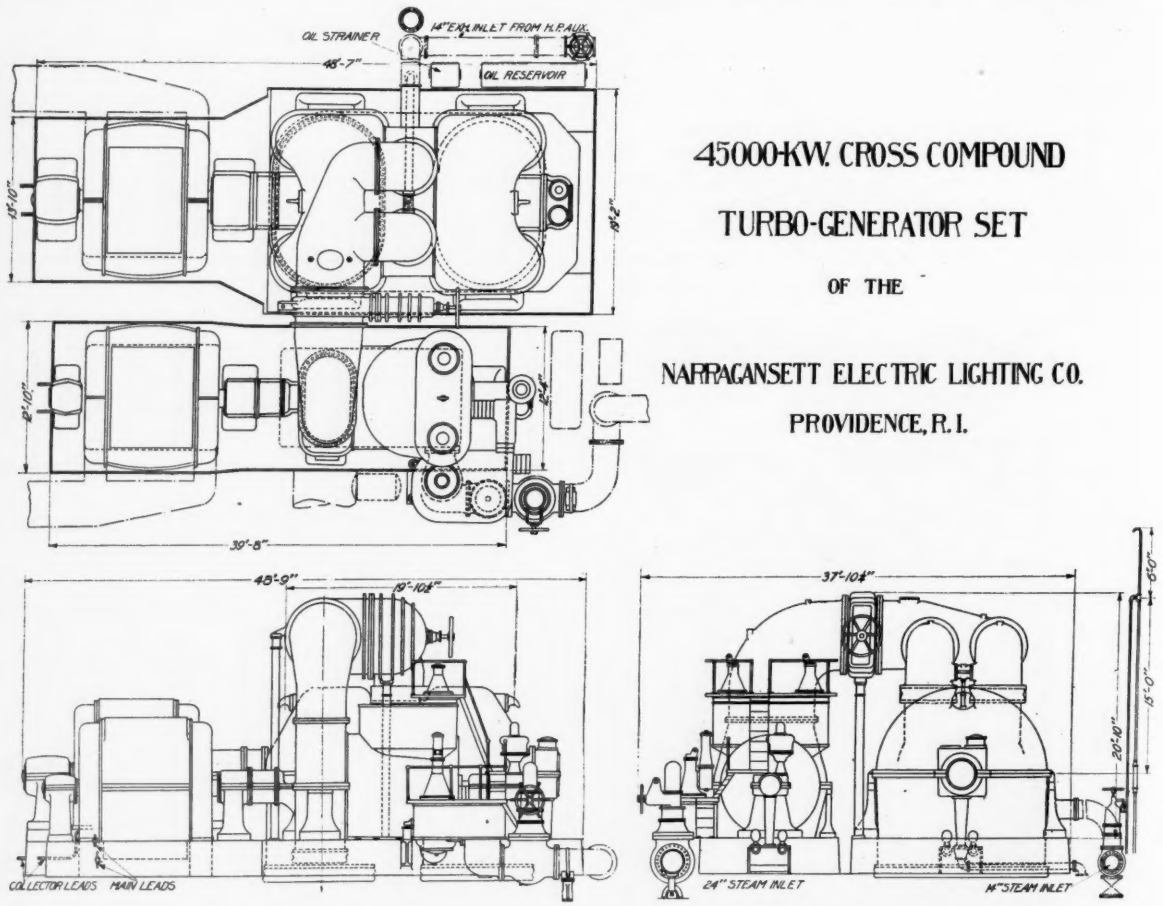


FIG. 2. PLAN AND ELEVATIONS OF CROSS COMPOUND TURBINE

High-Pressure Element

The high-pressure turbine is of the single flow reaction type throughout, of a very simple, rugged construction, designed for efficiency and dependability, all parts coming in contact with high-pressure steam being made of cast steel, while the exhaust chamber and other parts not subjected to high temperature or stresses are of cast iron.

The pressure in the high-pressure cylinder varies from a maximum of about 200 lb. at the inlet to atmospheric pressure in the receiver pipe at full load.

With a reaction type machine, high-pressure steam is

are tapped alternately into upper and lower flanges registering with suitable bosses on the companion flange. This method permits of a closer spacing of bolts, removing less metal, and produces a stronger flange than by any other means. No gasket is used, the joint being scraped to a surface.

The four rings containing the blades are not an integral part of the main cylinder, but are made of separate castings jointed in the middle, resulting in simplicity of construction, freedom from strains and the absence of those difficulties inherent in a complicated steel casting, besides being a distinct aid in manufacturing, as the machine work is not all done on one piece, but can

be divided among different machines, and finally assembled when each piece is completed. These rings are clamped in place, again saving expensive work on the main castings.

The high-pressure cylinder is supported on three points, as usual, one under the governor or thrust end and one on each side of the exhaust, near the center line, thus insuring against distortions or a possibility of misalinement, due to differential expansions between the turbine and generator supports from unequal temperatures.

The high-pressure spindle consists of a hollow steel drum about 3 ft. in diameter, carrying most of the blading; there are two blade rings of larger diameter on the one end, and corresponding dummy rings, or balance pistons, on the other. The spindle ends are pressed into the drum and are secured with tee-headed shrink links, which are themselves held in place by the blade and dummy rings.

The stresses in the spindle parts are quite low, these parts being made from ordinary carbon steel. However, strict care is taken in making the castings in order to insure homogeneity, the precautions necessary to secure this uniformity having been learned by long experience.

There are 24 rows of blades in the high-pressure turbine, ranging in size from 1-in. blades, 4 in. long, to 1¼-in. blades, 9½ in. long. These blades are unusually strong and rugged, and they insure the highest efficiency and durability. The maximum mean blade speed is 470 ft. per sec.

The steam passes out through an exhaust at the top of the cylinder into a 66-in. receiver pipe leading over to the low-pressure turbine. A similar exhaust is provided directly below, which connects through an automatic relief valve to the atmosphere.

A gate valve is placed in the receiver pipe, in case it is necessary to operate either turbine alone, the high-pressure turbine running non-condensing, under control of its own governor, or the low-pressure turbine, on steam admitted through a 14-in. throttle from the high-pressure line, it being connected in step electrically with some other unit in the system.

Steam is supplied to the unit through a 24-in. header, every care being taken to provide adequate flexibility to the line. A standard type throttle valve with the regular automatic stop features controls the admission. The throttle valve, steam strainer and primary steam chest, which are located adjacent to the bedplate alongside the turbine, are spring-supported, so as not to impose a dead load on the cylinder.

Double Flow Low-Pressure Element

The low-pressure element is of the straight double flow reaction type. The steam entering at the top through the above mentioned receiver pipe, passes around the spindle in an annular chamber of ample proportions, and enters the low-pressure blading, there being eight rows in each end, ranging from ¾-in. blades 6 in. long to 1¼-in. blades 18 in. long.

The low-pressure cylinder rests on four supports applied near the center line on each side of the exhaust chambers. It is free to expand axially, sliding on these supports, the turbine being anchored to the inboard generator pedestal. A system of radial and axial stays in the exhaust chamber produces extreme rigidity, minimizing the possibility of distortion or sympathetic vibrations.

The low-pressure spindle is composed of a central hollow drum, rigidly secured to the spindle ends. Upon each of these ends are mounted two disks carrying the low-pressure blades, the maximum mean velocity of which is only 515 ft. per sec., which precludes the necessity of using other than a reasonably good grade of cast steel in the blade rings. However, owing to the double-flow feature, ample blade area is provided to make the best use of a high vacuum and still maintain a conservative blade length in the last rows. Phosphor bronze blades are used throughout, except the last three rows in the low-pressure, which are forged steel.

The low-pressure cylinder is entirely of cast iron, composed of a center section and two end sections, bolted and spigoted together, and all split horizontally. The three upper pieces are handled as one, the vertical points never being disturbed.

The high-pressure steam admission is controlled by means of a powerful though sensitive governor, which operates the plunger of an oil relay attached to a floating lever, this relay controlling the admission of oil to an operating cylinder mounted on the side of the first, or primary, valve. This cylinder, by means of levers, controls the primary, secondary and tertiary admission valves. The primary valve, located on the side, admits steam to the bottom to the high-pressure cylinder, while the secondary and tertiary valves, being located on the top symmetrically about the center line, admit steam to the second or third stage, as the case may be. Loads of 30,000, 40,000 and 50,000 kw., respectively, can actually be carried on these valves.

Bearing Details

The bearings employed on this unit are carefully proportioned to preserve a satisfactory ratio between unit pressure and peripheral speed. They are lined with genuine babbit metal, supported on spherical seats and provided with positive adjustment in any direction. A liberal supply of oil is distributed through a groove along the top, while the sides of the bearings are eccentrically relieved for a distance of 35 to 40 deg. above and below the center line. This leaves an arc of 100 to 110 deg. on which the journal actually rests.

Both turbines are equipped with double thrust bearings capable of taking the load in either direction, though when running under load the thrust is toward the generator. Under normal operation they are loaded to about 300 lb. per sq. in., but are capable of safely carrying twice as much. The maximum peripheral speed is about 100 ft. per sec. These bearings are not only immersed in oil, but they are supplied with a circulation of fresh oil through passages which deliver it near the center.

The shafts are sealed with the usual well-known water gland, with the addition of an annular steam chamber for the admission of steam, so that a vacuum can be established before starting up. Water is turned on when the turbine approaches full speed and the steam is turned off. One feature of the glands is that they can be removed for inspection without lifting the cylinder cover.

Each turbine is provided with an oil pump sufficient for its own needs, though both feed into the same oiling system. They are double plunger pumps, running at 165 strokes a minute, with a common suction, but separate discharge.

The high-pressure oil necessary to operate the steam inlet valves is taken from one side of the pump on the high-pressure turbine, pressure being maintained by a spring loaded relief valve. The total amount of oil used is approximately 175 gal. a minute. The bearing oil pressure is from 5 to 8 lb.

This unit, although it does consist of two separate elements, is started the same as any other machine. Field excitation is supplied to the generators, the throttle on the high-pressure element is opened and slowly brought up to speed, the low-pressure generator operating as a motor, and coming to speed in step with the other. The two machines as a unit can then be synchronized and placed on the line, remaining in step and properly dividing their load.

temperature of the injection water is low enough to warrant it, the operation of only one condenser is necessary to maintain a workable vacuum.

These condensers are connected to form a single condensing apparatus by means of an exhaust connection, ample in area to permit operating either condenser alone, when necessary.

The same water level is maintained in each condenser by the use of a water-equalizing connection between one pump body and the other. This is an absolutely necessary feature, and it is provided in order to maintain a constant submergence over the center line of each pump, to provide sufficient head to force water into the runner under vacuum. This water-equalizing

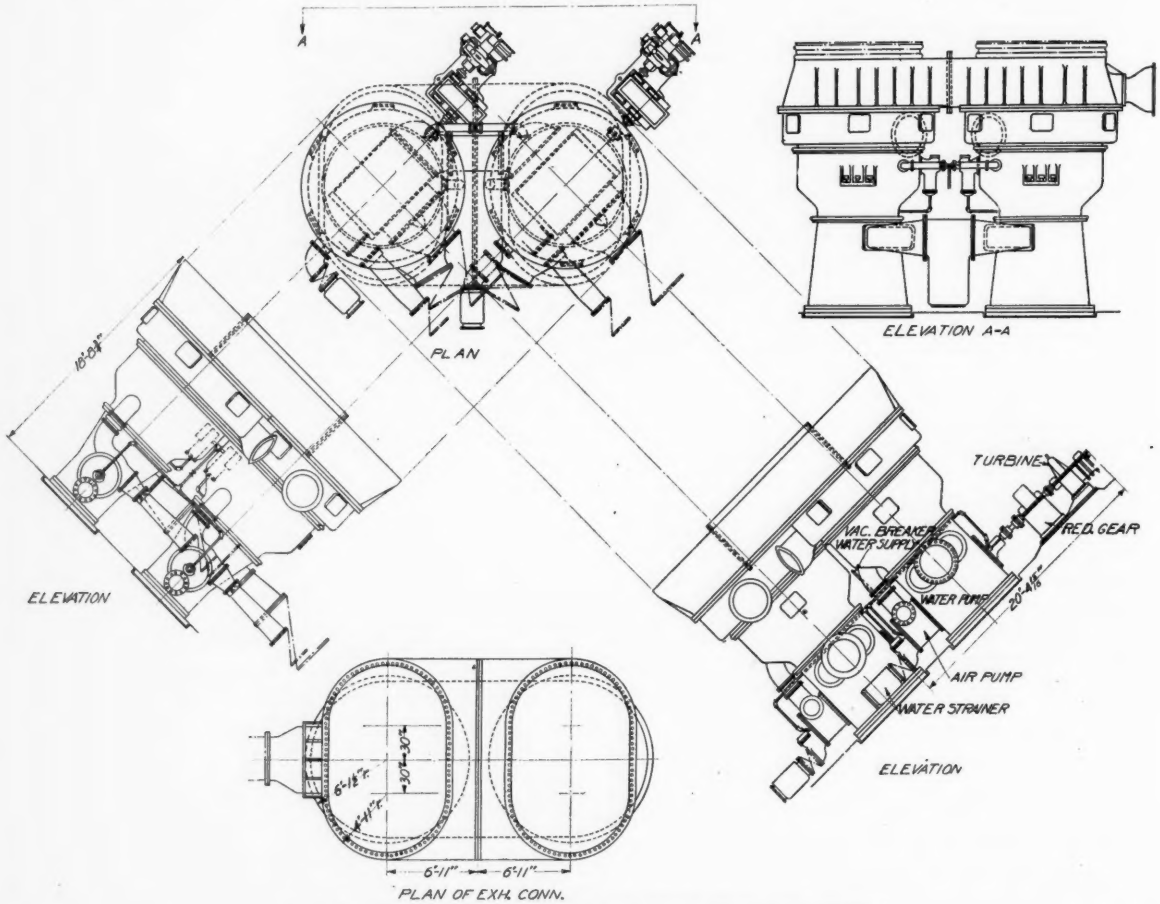


FIG. 3. PLANS AND ELEVATIONS OF THE CONDENSER UNIT

Two Condensers as a Unit

The condenser equipment for the above-mentioned turbine consists of the largest condensing apparatus in the world. The condenser unit is composed of two separate and distinct low-level jet condensers, which can be operated together or separately, if necessary. If the connection is so constructed that no surges occur between the condensers, being made in the form of a toe, the bottom of which forms a reservoir. A baffle running almost to the bottom prevents surging.

An air-equalizing connection is provided to maintain the same air pressure in each condenser. If both are in operation the valve may be either open or closed, but it has been found by trial that if one condenser only is in operation the valve must be open in order to have the same air pressure in each.

The condensers are equipped with geared turbine-driven pumps, running at 500 r.p.m. instead of 700 r.p.m., which latter is standard. This was found neces-

sary, owing to the limited headroom in the basement. These pumps are able to operate with a submergence of 50 in. above the center line of the pump shaft, while 72 in. is necessary with a 700-r.p.m. pump. This resulted in a saving in headroom of 22 in.

Considering capacity, this unit requires less floor space than any other condenser unit now in operation.

In starting up this condenser it is necessary to use a priming pump. The main turbine is operated non-condensing, or with a slight vacuum, until sufficient vacuum is obtained for the condenser to lift is own water.

The operating company has found it convenient in winter time, when the temperature of the injection water is very low, to operate only one condenser of the twin outfit, and still maintain the vacuum desired, thereby cutting the cost of operation in half. In cutting the condensers out it is only necessary to close the discharge and injection valves to the condenser not in operation and to operate the other independently.

As a matter of interest, it may be well to note that the above concern uses nothing but jet condensers. Its experience has been that, while boiler feed water is expensive, nevertheless surface condensers do not stand up under the extremely bad water conditions existing at Providence, and it is necessary to employ jet condensers.

The twin condensers used with the above 45,000-kw. turbine require 18,000,000 lb. of condensing water per hour, 9,000,000 lb. in each condenser. In addition to this, 15 per cent more is required for the operation of air pumps.

Lubricants for the Power Plant

QUALITIES OF A GOOD OIL; TESTS FOR GRADE OF OIL AND GRADES FOR VARIOUS USES. BY REGINALD TRAUTSCHOLD

FORTY to fifty million tons of coal wasted each year in our power plants—an accusation made by qualified experts—is a matter of grave importance, whether it be viewed in the light of money squandered or as a profligate extravagance of a great natural resource. This is coal that should not be burned at all; coal wasted through failure to employ a suitable grade of lubricant which is responsible, on the average, for the unnecessary consumption of 15 per cent of the coal used in power plant operation.

Technical and engineering skill has been expended in solving mechanical and constructional problems, overlooking in great measure the more pronounced economies presented in the lubrication field. The average 1000-hp. plant, operating 10 hr. a day, will in the course of the year consume approximately 3500 tons of coal, of which over 500 tons are burned unnecessarily.

Progress in mechanical development must necessarily outstrip the evolution of suitable lubricants, it is true, but the engineers of the leading lubricant producers are continually at work in their laboratories or compiling and standardizing records of lubrication service, hence the proper lubricant for any new equipment is evolved almost as soon as a demand has been created. It is the dissemination of the lubrication knowledge gained through the investigations of these lubricant specialists that is of first importance, but second only to this educational work is the obvious requirement that lubricant producers sell lubrication rather than lubricants.

Purchasing of lubricants on specifications cannot alone assure selection of the suitable lubricant in even the majority of cases. In the first place, the small consumer does not, as a rule, purchase on strict specifications, nor do any of the specifications so far drafted offer assurance that an oil meeting such specifications will prove to be the best suited for the requirements. Also comparatively little authentic lubrication information is available, and reliance must be placed on experiments and mechanical tests in the selection of oil lubricants. Such investigations can only be effectively conducted by experts with facilities at their disposal and recorded data covering the development of scientific lubrication.

Recommendations from reputable lubricant experts must be heeded, but comparatively simple tests can be conducted in the power plant whereby the lubricating qualities of oils can be checked, if not actually ascertained.

Essential Properties of a Lubricant

Regardless of the particular service a lubricant is to discharge, it should possess six essential properties, to function effectively.

1. Body, or viscosity, sufficient to prevent contact of bearing surfaces.
2. Freedom from corrosive acids.
3. As much fluidity as is consistent with body.
4. Low coefficient of friction.
5. High flash and burning points.
6. Freedom from substances likely to cause gumming or oxidation.

An oil for any particular service measuring up to these requirements would of necessity be durable and stable, additional requisites for a suitable and effective lubricant. The first and third of the listed essentials involve the specific gravity of the lubricant and its viscosity, a combined measure of its adhesive and cohesive properties. The second of the requirements is a negative one, easily gaged, and so generally conformed to by high grade lubricants that it may be accepted as an inherent property of any quality lubricant. The fourth essential, low coefficient of friction, is an attribute of a good lubricant and is possessed to a high degree by all mineral oils (petroleum products), so that any lubricant composed in large part of mineral oil conforms to the requirement. Flash and burning points, also the "cold test" of an oil, are governing factors in establishing its practical value as a lubricant, while the requirement of freedom from substances likely to cause gumming or oxidation is met by any straight mineral oil, or any permanent blend of oils containing a large proportion of mineral oils.

Classification of oil lubricants is then dependent upon five factors, in addition to the variety of oil—whether mineral or animal—by which they are commonly specified. 1. Specific gravity; 2. Flash point; 3. Fire point; 4. Cold test; and 5. Viscosity.

Specific Gravity

This is the ratio, by weight, of a given volume of the oil to that of an equal volume of pure water at the standard temperature of 60 deg. F. The measure used almost exclusively in the oil trade is the Baumé gravity scale. At 60 deg., the Baumé hydrometer reading for pure water is 10 and the scale reads higher for lighter fluids and lower for heavier ones. Baumé hydrometer readings should be taken at 60 deg., or, if taken at other temperature, corrected to standard value with the aid of a Baumé Gravity Temperature Correction Table. For check readings, however, it is customary simply to deduct a unit for each 10 deg. temperature in excess of 60 deg. F., or add a unit to the hydrometer scale reading for each 10 deg. under 60 deg. F.

Flash and Fire Points

Flash point of an oil is that temperature—arrived at gradually—at which vapor is expelled from the oil in sufficient quantity to flash, or ignite momentarily, when a small flame is passed over the surface of the oil. Fire Point is the temperature at which the oil will ignite and burn continuously when a small flame is passed through the fumes rising from the surface of the oil.

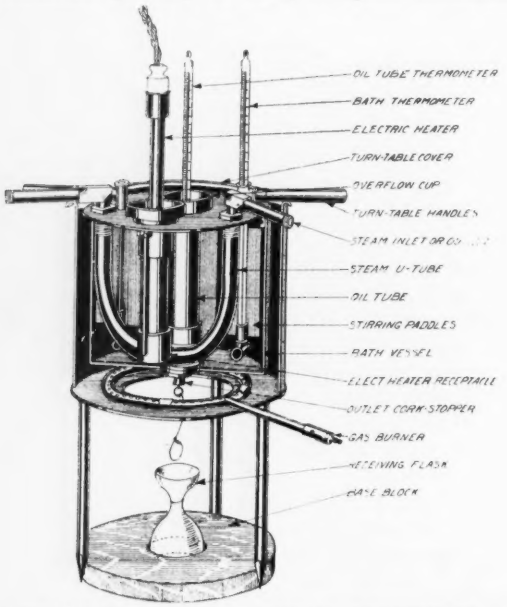


FIG. 1. THE SAYBOLT STANDARD VISCOSIMETER

Tests for ascertaining these two critical temperatures are simply conducted. A sample of the oil is placed in a small, open mouth cup—usually of seamless brass—over which, and extending into the oil, is suspended a thermometer for noting the rise in the temperature of the oil as it is gradually heated. As the temperature of the oil approaches its flash point, a small flame is swept over the surface of the oil and the oil temperature at which the first flash of blue flame takes place is noted. Such oil temperature is its flash point.

Continuing the heating, the temperature at which the test flame passed over the oil surface actually ignites the oil is the fire point.

Cold Test

As considerable misunderstanding exists as to just what the cold test of an oil signifies, the two steps which occur in the case of paraffine-base petroleums have been differentiated as the Cloud Test and the Pour Test, the latter establishing the cold test measure.

Petroleums of paraffine base become cloudy in appearance when cooled below a certain temperature, due to the separation from the oil of fine particles of paraffine. The temperature at which this becomes noticeable to the eye marks the cloud test. Further reduction in temperature will, of course, result in solidifying (freezing) the oil, and the lowest temperature at which the oil will "run" measures the pour test, the true cold test of the oil.

To conduct the cloud test, a few ounces of the oil to be tested are placed in an open mouth bottle, which in turn is placed in a tin holder protected by a wrapping of blotting paper. The holder is then immersed in a cold brine solution and the temperature at which the oil commences to become cloudy is noted. For the pour test, the oil is placed in a test tube fitted with a cork through which the testing thermometer passes. The depth of the oil in the tube should be about 2.5 in. and the bulb of the thermometer should extend to within 1 in. or so of the bottom of the test tube, 1.5 in. below the surface of the oil. The "pour test" temperature is noted at which the oil will no longer flow when the tube is tilted. Since the movement of the oil becomes very sluggish as its congealing temperature is approached, it is customary to take the cold test temperature as 5 deg. lower than the temperature F. at which the oil becomes so stiff that no movement can be observed for 10 sec.

FIG. 2. COMMON FORM OF HYDROMETER

FIG. 3. FLASH AND FIRE TESTER

Viscosity

Viscosity of an oil is the measure of its fluidity, or body, and is closely related to the physical properties of adhesion and cohesion. A viscosimeter is necessary for ascertaining this all-important measure, the instrument used almost exclusively being the Saybolt visco-

simeter. The instrument consists essentially of an oil receptacle of standard shape and size immersed in a bath of oil or water. Means are provided to maintain the temperature of the bath at the testing temperature and the viscosity of the oil is determined by the length of time required for a measured amount of oil at testing temperature to pass through a bottom orifice of the oil cup. The time in seconds for the passage of the oil records the viscosity of the oil.

When testing cylinder, valve and other oils subject to high temperatures in service, the standard testing temperature is taken at 212 deg. F., but for the majority of other oils, the testing temperature is taken as 100 deg. F. In the case of oils tested at 212 deg., the temperature of the bath, usually a pale engine oil of about 375 deg. flash point, is maintained at 212 deg., but the temperature of the oil tested is customarily about 210 deg. F. The temperature of both the bath and the oil should be the same, 100 deg. F., when the testing temperature is 100 deg.

The viscosity test is not, as a rule, feasible in a power plant, unless a testing laboratory is maintained; but the flash, fire and cold tests can usually be performed with some degree of accuracy without special equipment. An oil lubricant which measures up to requirements in the three simple tests might not possess the required viscosity, it is true; but if the quality of the oil is known to be good, the chances are that the body of the oil is likewise satisfactory. However, there are a number of additional simple tests which can readily be made that will show up any failings perhaps more than establish a measure for viscosity, but which are nevertheless strong indications of the suitability of the oil for lubrication service.

Acidity Tests

Some engine and machine oils are treated with sulphuric acid during the process of refinement, any surplus of which in the form of free acid in the oil is ample ground for condemning the lubricant, its presence being due to improper refinement. Such free acid content is readily discovered by simply washing a sample of the oil with warm water and testing the wash with neutral litmus paper. Even a faint reddish tint to the paper should cause rejection of the oil. Another simple method of acid detection, is to immerse a piece of highly polished copper in the oil for 24 hr. A trace of acid is sufficient to cause the surface of the metal to become dulled.

A sensitive test for the presence of sulphuric acid is to dilute a small quantity of the oil with an equal amount of high gravity gasoline and add a few drops of a saturated solution of barium chloride. The presence of sulphuric acid is denoted by the formation of a white deposit or precipitate.

Evaporation Test

Stability of an engine oil or cylinder oil is readily ascertained by simple evaporation tests. In the case of engine oils, a measured sample is heated to 212 degrees F. in a shallow dish and kept at such temperature for 4 hr. If at the end of such period the oil has lost more than ¼ to ½ per cent in weight, it is unsatisfactory and unsuitable for economic lubrication. Cylinder oil should be maintained at a temperature of 400 deg. F. for 24 hr., in which time a good cylinder oil should not lose more than 2 per cent in weight.

Test for Animal Oils

Presence of animal oils in a mineral oil lubricant may be detected by heating a small quantity of the oil mixed with an equal quantity of borax, caustic soda or caustic potash for about 15 min. The presence of animal oil is denoted by a light yellow deposit. A common test is to rub a few drops of the oil between the hands. The frictional heat produced will cause the animal oil, if present, to give off a decided and rather offensive odor.

Quality Test

For an oil lubricant, a quality test, as regards the thoroughness of its refinement, is to fill a clean bottle with the oil under observation and heat it slowly over an open flame until visible vapors are driven off. The heating should then be continued for about 15 min., maintaining a constant temperature. A well refined oil will darken, but remain clear and free from sediment, if allowed to stand for 24 hr. A poorly refined oil, on the other hand, will turn black and during a 24-hr. stand a black carbon-like deposit will form. The deposit denotes the presence of sulphuric or sulphonic acid compounds, an unstable oil and one that should be rejected.

Suitable Oil Lubricants

Though many, if not all, the foregoing oil tests can be conducted with the facilities afforded in the average power house, they are of little value unless some standard of comparison is provided. The quality of the oil can be ascertained well enough, but the suitability of the lubricant does not necessarily follow. For one kind of service, a lubricant might be eminently suitable, but for some other service quite unsuited, though the oil was of the highest grade. Quite obviously, a special oil lubricant for each condition of service is impractical, but classes of service can be formed and the suitability of different oils (lubricants) presented for the various classes.

Engine Oils

Numerous engine oils on the market possess a wide range of effectiveness; but though there is need for several grades of engine oils, they may all be classified in three general groups—the medium body engine oils, heavy oils and the compounded lubricants—each of which has its particular field of usefulness in the power house, bounded by fairly definite specifications.

Medium body engine oils are to be recommended for use where the rapid separation of the lubricant from entrained water is essential, as in continuous oiling systems, and for crank case engines where steam escaping into the crank case condenses and mixes with the lubricant. High speed and fairly high speed engines—such as the Phoenix, Ide, Ideal and Harrisburg—common in modern power house service are best served with medium body engine oils. The lubricant should be straight mineral oil of a specific gravity (Baumé scale) somewhat less than 30, preferably, and not more than 25. The Saybolt viscosity should run from 150 to 225 at 100 deg. F., the higher viscosity for the better grades of lubricant, and the flash point should be in the neighbor-

hood of 400 deg., with a fire point some 50 deg. higher. The cold test should occur at about 30 deg. F.

Three grades of medium body engine oils that have proved eminently satisfactory in service meet the specifications listed in the accompanying table. The oil designated by the symbol A is the most effective and is a filtered oil of pure Pennsylvania stock. It separates readily from condensed steam and is an excellent lubricant for large high speed engines requiring a plentiful oil supply. Oil B, also a pure filtered mineral oil, is of somewhat lower viscosity and is particularly suitable for high speed engines of smaller size. Oil C is a straight mineral oil that is admirably suited for use in the smaller power plants where the engines are kept in good running condition and operated at a fairly high speed.

TABLE I.—MEDIUM BODY ENGINE OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec. at 100 deg.
A	30.5	410	460	30	210
B	32	395	445	30	150
C	25	375	425	35	180

The three engine oils are effective, economical and efficient lubricants for the bearings of almost any type of high, or fairly high, speed reciprocating engines. They differ considerably in price, but the price of each is well warranted for the service recommended. The variations in the physical properties of the different oils, furthermore, indicates the danger of too great reliance upon strict physical and chemical specifications in the selection of engine oils. All three oils are to be recommended and the respective specifications form excellent standards by which to purchase medium body engine oils.

Straight mineral oils should also be used for heavy, slow moving bearings of power plant engines which are subjected to comparatively high temperatures, but oils of considerably greater viscosity, though lower specific gravity, than the engine oils classed as of medium body. The Saybolt viscosity should exceed 250 in the better

TABLE II.—HEAVY ENGINE OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec. at 100 deg.
D	26	440	480	40	325
E	24	420	470	40	280
F	23	410	460	35	285
G	24	400	450	35	245

grades, running as high as 325 at 100 deg. F. Flash and fire points should be high and the specific gravity in the neighborhood of 25 deg. Baumé. Four recommended grades of heavy engine oils are listed in Table II.

Oils D and E, both straight mineral oils, will function effectively under any degree of temperature encountered in heavy engine bearing service, oil D being exceptionally effective, but at the same time quite expensive. Oil E is of almost as high a grade as D and E, but of slightly less body, while oil G is a good grade of engine oil suitable for ordinary service. In fact, an engine oil of about the specifications for G is quite generally employed and, as a rule, renders effective service. It is considerably cheaper than the other more expensive and effective heavy engine oils, on account of its much lower viscosity.

For heavy bearings supplied from drip cups and subjected to high temperatures, a compounded engine oil is frequently to be recommended and proves more effective than a straight mineral oil. Such oils should be compounded of high grade mineral oils and about 5 per cent of lard oil. Lard oil adds to the cost of the lubricants, as the combination must be permanent in service and lard oil is quite expensive. The peculiar unctuous property of lard oil, however, increases the adhesiveness of the product and gives to it high heat resisting capacity. Two grades of compounded engine oils for hot running heavy bearings are specified in Table III.

Cylinder Oils

Effective lubrication of the cylinders and valve gears of reciprocating steam engines presents the most difficult lubrication problem of the power plant. The service demanded of the lubricant is unusually severe, high temperatures and wide variations in temperatures are encountered, pressures differ considerably and the distribution of the lubricant is made difficult by lack of control. The position of the cylinders, the construction of the valves, the steam flow and the ratio of expansion are all factors which have to be considered.

Without discussing requirements, it may be taken for granted that lubricant is fed to cylinders by the live steam at or before the point at which the steam enters the steam chest, the steam atomizing the lubricant and carrying it to all parts of the steam chest and cylinder with which the steam comes in contact.

As the atomizing of the cylinder oil is affected by the quality—wet or dry—of the steam, the temperature of the steam, the distance between the point of oil admission and the valve chest, the velocity of the steam

TABLE III.—COMPOUNDED ENGINE OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec. at 100 deg.
H	23.9	430	450	36	240
I	25.2	390	440	36	185

and the characteristics of the oil, it follows that, with other conditions the same, high pressure steam will atomize the oil more thoroughly than steam at lower pressure, that the viscosity of the oil governs to a certain extent the readiness with which it is atomized and that the point of oil admission can be varied to regulate the degree of atomization. As a rule, the heavier cylinder oils are used in engines operating on high pressures and, when plentiful lubrication is essential, it is more economical to employ a heavy oil introduced some distance back from the valve chest than a lighter oil introduced nearer to the moving parts. Filtering the oil also causes it to atomize more readily, so unfiltered cylinder oils should only be used where steam pressures are fairly high.

Unless the steam is highly superheated, so as to assure a dry exhaust, a certain amount of condensation occurs in the cylinder, resulting in a tendency to wash away any portions of lubricating film with which the wet steam may come in contact. For this reason, cylinder oils—other than those for use in engines operating on superheat—should be compounded products of a high

grade of mineral oil with a comparatively small proportion of animal oil. Addition of the animal oil gives to the compound an unctuous quality which combats the washing effect of the wet steam. For use under high superheat, however, the most effective cylinder oil is one of straight mineral oil stock.

Specific gravity of cylinder oils should not be more than 24.5 deg. nor less than about 27 deg. Baumé. This range covers both compounded and uncompounded (straight mineral) cylinder oils.

Table IV. lists specifications for effective grades of compounded cylinder oils and for an excellent straight mineral (uncompounded) cylinder oil suitable for practically any type of reciprocating engine operating on high superheat. Oil A, Table IV, is very heavy and suitable for high-pressure engines operating on low superheat, i. e., engines operating on dry steam. Oils B, C, D and E are all heavy, but each has its particular field. Oil B is particularly effective for Corliss type engines operating on dry, or low superheat, steam at from 175 to 200 lb. gage pressure. Oil C is to be recommended for quite similar service, but for steam pressures of from 150 to 175 lb. It is also an admirable

TABLE IV.—CYLINDER OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec. at 212 deg.
Compounded					
A	24.5	620	690	44	250
B	25	550	610	34	150
C	26	550	610	78	130
D	26	520	580	65	128
E	26	560	620	30	140
F	26	550	620	50	138
G	26	520	580	65	116
H	26	560	620	30	155
I	26.5	550	610	38	135
J	27	490	550	80	95
Uncompounded					
K	24.5	630	700	40	375

cylinder oil for Erie Ball engines. Oil D is compounded with acidless tallow oil and is recommended for wet steam service under variable load. Oil E is also compounded with acidless tallow oil and suitable for use with wet steam, but is unfiltered.

The specifications for oil F call for a fairly heavy oil, highly filtered and free flowing, for general use. Oils H and I are medium body cylinder lubricants for general use, oil H being somewhat the better grade and slightly higher in price. Oil J is of light body and suitable for all types of reciprocating engines using steam under low pressures—from 110 lb. gage down.

Crank Case Oils

In certain types of reciprocating engines, the crank cases become filled with condensed steam and a special crank-case lubricant should be employed that will resist the wash of the water and still filter readily from the water. The same condition exists in many engines where the cylinders have become worn and steam leakage excessive. A pure mineral oil is necessary in order to avoid emulsification. Specifications for two grades of effective crank case oils are given in Table V.

Oil symbolized as A is particularly effective for use in the crank case of Westinghouse type of engines, where oil is floated on the water in the crank case. It is also an excellent lubricant for the crank cases of engines given to excessive cylinder leakage. Oil B is somewhat lighter in body, less expensive and somewhat less durable, but a crank case oil that filters rapidly and separates clear from water.

Turbine Oils

Oils suitable for turbine lubrication must filter rapidly and clear from water. In fact, the capacity to separate quickly from water is one of the main requisites of an effective turbine oil. The oil should be clear and filtered through Fuller's Earth. For large turbines (5000 kw. up), a heavy oil is most effective, but for

TABLE V.—CRANK CASE OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec.
A	26.5	430	490	30	75 at 212 deg.
B	32	395	445	25	150 at 100 "

smaller units the oil should be of medium viscosity. The oils specified as A and B, Table VI, are excellent turbine oils for units of more and less than 5000 kw. capacity, respectively.

Dynamo and Motor Oils

Effective lubrication of dynamos and motors is not infrequently found to be far from a simple matter. The trouble is usually an attempt to economize by employing the same grade of lubricant for all sizes of electric units. High grade lubricants are essential, but the grade of oil for effective lubrication is governed largely by the size of the machine. For practical considerations, however, four grades of oils are sufficient to care economically and effectively for the lubrication of from the smallest to the largest generators or motors found in the average power plant. Four effective and efficient lubricants are specified in Table VII.

Oil A, Table VII, is of high viscosity and is suitable for very heavy units; oil B, of good viscosity, is adapted

TABLE VI.—TURBINE OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec. at 100 deg.
A	30.5	420	470	20	200
B	32	395	445	31	150

for heavy units with ring-oiled bearings; oil D, medium body, is best suited for all ordinary (medium) sizes of dynamos and motors; while oil E, light viscosity, should be used only for small motors.

Air Compressor Oils

Dry heat encountered in air compressor service necessitates the use of only particularly stable lubricants. The specifications for three high grade air compressor oils are given in Table VIII.

Oil A is a very heavy, filtered straight mineral oil. It is unusually free flowing for such a heavy oil and is intended for service where the temperature in the cylinders is above normal (325 deg. F.). Such temperature is common in many single-stage compressors, particu-

larly after the equipment has been in service some time, and for such units an oil of the grade of A should invariably be used. Oil B is also a filtered oil, intended for use in multistage compressors where the temperature is high. It is also an excellent lubricant for new well-cooled single-stage machines. Oil C is of medium viscosity and is intended for well-cared for multi-stage machines that are tight.

Gas Engine Oils

Pure mineral oils should be used for the lubrication of gas engine cylinders, for the heats encountered are

TABLE VII.—DYNAMO AND MOTOR OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec. at 100 deg.
A	30.5	420	470	20	200
B	31	400	450	20	180
C	32	390	440	30	140
D	27.5	345	395	18	90

intense and very dry. This necessitates specially refined oils of high flash and viscosity.

Oil A, Table IX, is a heavy mineral oil meeting the exacting requirements developed in large stationary gas engines. Oil B is slightly lighter and is an excellent oil for similar service when initial lubricant expense is of greater importance than the better wearing qualities of the more expensive oil A. For smaller engines, oil C is both economical and effective, while oil D is intended for use in the smaller sizes of gas engines operated out-

TABLE VIII.—AIR COMPRESSOR OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec.
A	26.5	500	550	55	115 at 212 deg.
B	29.5	440	490	35	385 at 100 "
C	31	400	450	20	180 at 100 "

of-doors. These four oils are particularly satisfactory, in that they are comparatively free of the common gas engine oil failing of carbonizing the cylinders.

Machine Oils

Finally, every power house is affected by the quality of the machine oils employed. These important lubricants should be pure mineral oils and several grades should be employed if a variety of shafting, etc., has to be cared for. Table X lists specifications for some

TABLE IX.—GAS ENGINE OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec. at 100 deg.
A	24.2	415	465	40	405
B	24	410	460	47	340
C	25.5	400	450	50	250
D	23.9	400	450	35	285

eight high grade machine oils, each one of which has its own particular field of economic service.

Oil A is an all around lubricant to be highly recommended for all bearings on practically any machine. It is a high grade and expensive oil, but of unusual wearing qualities. Oil B, also high grade and expensive, is prepared for lubricating heavy slow moving bearings and flat rubbing surfaces, for which service it is economical despite its high cost. Oil C is another all around machine oil, slightly lighter than oil A, for use on bearings running at high speed with medium loads, or for high speed ring-oiled bearings. An oil meeting the specifications for oil D is suitable for shafting in general and all ordinary mill lubrication. Oil E is a heavy oil for all around lubrication, but not of the grade or quality of oil A. The next oil in the list is suitable for heavy slow moving bearings and the lubrication of flat rubbing surfaces, but like oil E ranks but as second quality as

TABLE X.—MACHINE OILS

Symbol	Specific Gravity Baume	Flash Point Deg. F.	Fire Point Deg. F.	Cold Test Deg. F.	Viscosity Saybolt Sec. at 100 deg.
A	24	400	450	35	245
B	25	430	480	43	300
C	25	380	430	35	180
D	25	375	425	30	175
E	27.5	345	395	18	90
F	26	410	460	40	235
G	26	400	450	38	210
H	30	375	425	35	175

pertains to wearing qualities. Oil G is quite similar, but of somewhat lower grade, while oil H is a relatively cheap oil suitable for shafting and ordinary mill lubrication.

Many Professions Taught Disabled Soldiers

There seems to be a general impression that the re-education and training given disabled soldiers, sailors and marines by the United States government is wholly in the manual trades. Just where this impression originated is hard to say, but possibly on account of the general understanding that vocational education means instruction in wood working or machine shop work, or something of the sort. As a matter of fact, out of the first 787 disabled veterans placed for re-education by the federal board of vocational education at Washington, which is the agent of Congress in providing this free re-education for these men, a considerable number are in the professions, pure and simple.

There are 23 illiterates taking elementary academic education; college academic education, 2; architecture, 6; art, 2; taking chemistry, 3; dentistry, 2; drafting, 2; engineering, 54, which is divided up into the following sub-heads: architecture, 4; chemistry, 1; civil engineering, 7; electrical, 18; general, 6; mechanical, 15; mining, 2; steam, 1. Two are taking a course on foreign trade; 2 have taken up forestry; 7 are taking a course in journalism; 3 landscape gardening; 6 are studying languages, and 19 are studying law. There are 8 men qualifying as doctors of medicine; 21 are taking mechanical drawing, and 4 are taking music. There are 4 of the men taking a course in pharmacy; 1 is studying the technique of the publishing business; 12 are studying salesmanship; 10 are taking secretarial work; 3 are qualifying as teachers; 7 are taking trigonometry; while 2 have taken up theology.

This education is given by the United States government absolutely free. It is obtained in the best institutions of the country, all fees paid and the student allowed $65 a month, support fund.

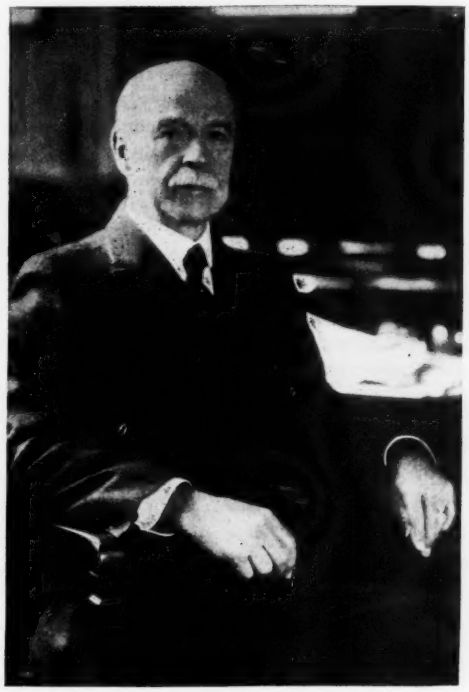
ROBERT W. HUNT

AN AUTHORITY ON METALLURGY, AN ENGINEER WHO MAKES SCIENTIFIC INSPECTIONS. GRADUATED FROM THE UNIVERSITY OF HARD KNOCKS AND ACHIEVED SUCCESS BY HARD WORK. BY PAUL CRISSEY

TUCKED away under the very roof of one of Chicago's skyscrapers, exactly one floor above the top of the elevator shafts, is a big, light office filled with busy clerks and earnest men. On the scores of desks in the private rooms may be seen scraps of steel, fragments of iron, cross sections cut from steel rails and a thousand and one other bits of metal, which, if one had not read the sign on the door, would convey the impression that some maniac with a propensity for collecting weird paperweights had just completed a successful night's work.

At the end of the long corridor which runs past the doors of these private offices is a heavy door, bearing the sign "Private." What lies beyond that mysterious blockade the casual visitor seldom finds out, but it is safe to say that somewhere behind the mahogany panel is an elaborate laboratory wherein the scraps of metal and the various devices which find their way into the office are subjected to intricate tests of a highly technical nature.

For the office is that of Robert W. Hunt & Co., consulting and inspecting engineers. The man who heads this institution which bears his name is known all over the world as one who has contributed knowledge of untold value in fundamental engineering work and made possible, as well as safe, some of the giant structures, mechanical and commercial, which mark the civilization of our times.



ROBERT WOOLSTON HUNT

Mr. Hunt is the apostle of scientific inspection and his reputation is international.

With all of the recognition which has come to Mr. Hunt in his engineering career, and despite his world-wide recognition as an authority on metallurgy, it is a significant fact that beyond the statement that he was born Dec. 9, 1838, in Fallsington, Pa., and received in 1912 the John Fitz medal for his contributions to the early development of the Bessemer process for making steel, the newspaper reference rooms contain no information about him. Those who know Mr. Hunt assert that this is not strange, although newspapers have yards and yards of biographical data on men of considerably less importance to the world than is Mr. Hunt.

Quiet, hardworking and interested is Mr. Hunt, who gained most of the knowledge for which he is honored now in the University of Hard Knocks.

Born with a keenly analytical mind and a mentality which he probably inherited from his father, Dr. Robert W. Hunt, who graduated from Princeton College in the class of 1824, young Mr. Hunt took a primary course in iron making in the old rolling mill at Pottsville, Pa. Even in those days the theoretical side of engineering appealed to him only as a natural adjunct to the practical side. His rise to an international place in engineering circles was due almost entirely to sheer strength of will.

In the old rolling mill, in the glare of the furnaces, he learned at first hand the mysteries of puddling, heating and rolling steel. He learned rapidly, and as knowledge came to him he became more and more eager to extend his education. Consequently, when an opportunity presented itself, he jumped in and took up the study of analytical chemistry in the laboratory of Booth, Garrett & Blair, in Philadelphia.

When his studies there were completed he entered the employ of the Cambria Iron Co., at Johnstown, Pa., and on Aug. 1, 1860, established, as a recognized department of that company, a laboratory which was the first one in this country to be a direct part of an iron or steel manufacturing organization. Then came the Civil War. Personal ambitions were forgotten in the new and greater duty which had arisen, and in the fall of 1861 he entered the service, was placed in command of Camp Curtin, at Harrisburg, served as mustering officer for the state of Pennsylvania, with the rank of captain, and in 1864 assisted in recruiting Lambert's Independent Mounted Company P. V., and was mustered into the service as a sergeant.

The toss of a coin prevented his obtaining a commission in this instance, for in order to decide whether he, or a friend who also had assisted in recruiting the company, should receive a commission as lieutenant, they

tossed up, with the result that Mr. Hunt went in as an enlisted man and the friend as an officer!

The war over, Mr. Hunt returned to the Cambria Iron Co., and was sent by them almost immediately to the experimental Bessemer Works at Wyandotte, Mich., and in 1865 was placed in charge of those works, where he continued for about a year, when he was recalled to take charge of the rolling of steel rails for the Pennsylvania Railroad—the first steel rails to be made in America on a commercial order.

His signal success in this work, together with several improvements which he made in the manufacturing of rails and the handling of steel, brought him some recognition, and when the Cambria Co. began the work on a Bessemer plant of their own, Mr. Hunt was called to assist in the designing and construction work. He assumed charge of the plant upon its completion, but left in 1873. His most important work between that time and 1888 was with the Troy Steel and Iron Co., for which concern he almost completely rebuilt the various works and erected one of the most complete blast furnace plants of the time.

His experience resulted in the patenting of various devices used today in the steel industry, devices which did much to advance that industry. His associates were John E. Fry, William R. Jones, Dr. August Wendel and Max M. Suppes. Much of his patented work, however, was done individually, and included both steel and iron metallurgical processes and machinery.

It was at this time that they built for the Troy Co. the first automatic rail mill tables, while later the Hunt-Jones-Suppes rail mill feed tables were used under license by nearly all of the rail mills in the United States.

In 1888 Mr. Hunt conceived and created the present Robert W. Hunt & Co., and established the main office in Chicago. Today this Bureau of Inspection, Tests and Consultation has branches in almost every city of importance in the world and, with its head, is recognized authority in the matters which it handles.

Mr. Hunt is a member of virtually every engineering society and institute in the United States and has been president of many of them. He also is the American member of the Council of the International Association for Testing Materials and holds honorary and active membership in many European societies of similar scope. His writings have been quoted widely, and in engineering circles are regarded as authoritative.

For many years Mr. Hunt has been a trustee of the Rensselaer Polytechnic Institute at Troy, N. Y., from which in 1916 he received the honorary degree of Doctor of Engineering.

It is typical, however, of this engineer that he lets his work speak for him. And this same principle he applies to others.

"What does Mr. Hunt think the keynote of his success is?" asked a friend one day in talking with one of the engineer's associates.

"Just plain work, I guess," replied the other. "I have never heard him make an epigram or give a young man any advice on how to succeed. He lets them go ahead and work it out for themselves, on their own initiative. That's what he does with his problems—and he always solves them."

The Doherty Training Schools

By Robert G. Griswold*

THE DOHERTY organization operates about 125 companies, many of them public utility companies and some of them producing and refining petroleum. The gross earnings of all of these properties for 1917 was about $70,000,000. The organization started from very small beginnings less than 15 yr. ago. The total payroll now numbers some 16,000 employes, more or less.

One essential element of so rapid a growth has been the ability to supply able men for its direction. The foundation for this was determined in a policy arrived at previous to the inception of the organization, which has always been adhered to. This policy was to consider the employes as material for advancement and to endeavor to help them advance and grow on every occasion. It became apparent, however, that the rank and file of employes of these organizations were not able to grow in ability as rapidly as would be required, largely on account of lack of educational foundation.

It therefore became evident that some outside help would have to be drawn in to supplement the supply from the original payroll, and payrolls of acquired properties. When it was decided to provide this supplementary supply a comprehensive scheme was outlined which contemplated the hiring of graduates of engineering colleges as being the most promising raw material. These men are given a period of intensive training consisting of short periods in each department, covering as many departments and in as minute detail as the period of about two years makes possible. During this practical experience the man works with the regular employes, under the same hours, and does the same work. He is paid, however, not on what he earns but on a contract salary designed to cover his living expenses.

It is found that the utility business, and more particularly the oil business, is so diverse that a man can learn for two years and yet not become proficient enough in any one department to be very valuable to that department. For instance, these men test and repair electric meters, gas meters, transformers, arc lamps, work on electric distribution system, the gas distribution system, the power plants, gas works, the office, taking contracts, keeping customers' accounts, on the general books, selling gas and electricity; in fact, every department into which they can be put. The practical work is paralleled by a series of discussions prepared and edited by the most competent men in the company.

Starting with one school at Denver, Colo., in connection with the Denver Gas & Electric Light Co., it has been necessary to establish a second one with the Toledo Railways & Light Co. and a third one in the natural gas and oil field at Bartlesville, Okla., in connection with the Empire Gas & Fuel Co., and a fourth one at Titusville, Pa., to teach the refinery business.

In the history of this work, since its beginning in 1906, more than 450 men have been hired, of whom not more than 15 per cent have left for employment other than in the great war.

In addition to very capable instructors developed within the organization, Prof. H. B. Shaw, at one time

* Chief Technologist, Henry L. Doherty & Co.

Dean of the Engineering School of the University of Missouri, and then a member of the Utilities Commission, devotes his entire time to the conduct of these schools, making his office with the Toledo Railways & Light Co. This training school has not taken precedence of the promotion of the regular employes in the organization, but the growth and development of the organization would have been impossible if the men originally within it were the only source from which to make promotions.

Of the first five classes, 1906 to 1910, inclusive, 34 are still with the organization, more than half of whom are managers of local properties or hold other positions of equal importance and responsibility.

Progress in Engine Economy

IT IS interesting, sometimes, to take a backward glance, and note what road we have traveled in our progress in the arts.

Visitors to the Centennial in 1876 gazed in wonder at the big vertical Corliss there exhibited; and well they might. It stood 40 ft. above the floor, on a platform 55 ft. diam. and weighed 607 T.; working at 70-lb. pressure and 26-in. vacuum, it developed 1400 hp. with an economy of 20 lb. steam, or 2.2 lb. coal per i.hp.-hr.

Another exhibition monarch was the 5000-hp. Allis-Corliss at St. Louis, and similar giants were installed in the New York Edison Co.'s plants, the record steam consumption going to 12 lb. per i.hp.-hr.

Later has come the Uniflow type, with a coal economy of 1.08 lb. per d.hp.-hr. at 130 lb. and 261 deg. F. superheat, but that record has been equaled by triple-expansion engines with steam at 170 lb. and 203 deg. superheat.

Highest of all steam engine efficiencies is that of the "locomobile" unit, which uses the exhaust gases from the boiler to jacket the steam cylinders. With 200 lb. pressure, the steam in the high-pressure has a temperature of 825 deg. and in the low-pressure of 475 deg., feed water being heated by an economizer in the breeching. A coal consumption of 1 lb. per d.hp.-hr. is common, and 0.8 lb. has been reached.

The steam turbine has reduced first cost and floor space of the prime mover, but shows about the same economy for like temperature ranges as the reciprocating engine. In size, the Ljungstrom machine of 1912, which gives practically the same power as the Centennial Corliss, was 5 ft. 1 in. long., 4 ft. 2.5 in. diameter, 5 ft. 4 in. high and showed an economy of 8 lb. steam or 0.9 lb. coal per d.hp.-hr. with pressure of 162 lb., 297 deg. superheat and 28.5 in. vacuum.

Prof. R. M. Anderson of Stevens Institute gives the accompanying table to show the best recorded performances of various types of prime movers up to the present time. The ratio in Column V is that of delivered energy to the performance of a perfect system working on the Rankine cycle.

BEST RECORDED PERFORMANCE OF PRIME MOVERS

Type of Engine	Steam per hour per D.H.P. lbs.	Coal per hour per D.H.P. lbs.	Ratio delivered energy to that in the steam — %	Ratio delivered energy to that of the coal — %	Ratio delivered energy to that of a perfect engine — %
	I	II	III	IV	V
Simple throttling non-cond. engine..	48.0	5.33	4.25	3.30	39.2
Simple automatic shaft govrn.....	38.0	3.60	6.58	4.60	47.8
Simple Condensing Corliss.....	19.75	2.15	11.10	8.33	53.1
Comp. Cond. Automatic Shaft Gov.	19.75	2.15	11.80	8.90	55.6
Simple Condensing Poppet.....	15.50	1.72	13.12	9.80	47.6
Marine Triple.....	14.5	1.65	15.5	11.00	53.4
Marine Turbine.....	11.4	1.40	18.6	13.00	61.5
Land Turbine.....	10.6	1.30	20.0	14.0	66.2
Comp. Cond. Corliss.....	10.05	1.11	20.2	15.0	72.2
Land Triple.....	10.08	1.12	19.8	14.6	65.5
Uniflow (Stumpf) Simple.....	9.0	1.08	22.1	16.8	73.1
Wolf Compd. Locomobile.....	8.9	1.00	22.4	17.5	74.1
Ljungström Turbine.....	8.0.	0.91	24.4	18.3	74.7

First Aid

IN CASE of accidents, the following points should be remembered:

1. In applying a bandage to a wound, do not let the part which comes against the wound touch the fingers or other unclean objects.

2. Paint iodine on the skin around the wound with a sterilized swab or pour alcohol over it.

3. Check bleeding with a tourniquet only when the blood is spurting from the wound.

4. Place the patient on his back in a comfortable position with head low; if cold, get him warm; if overheated, put him in the shade.

5. Learn the Schafer method of artificial respiration, and see that all employes know it; use it immediately in case of drowning, electric shock or suffocation.

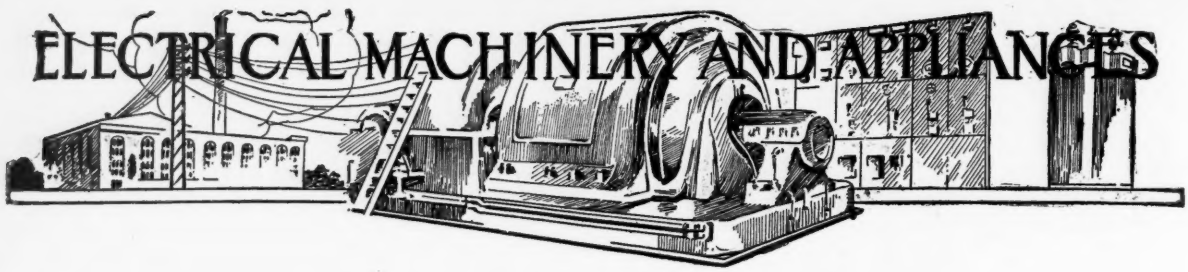
6. Fix a broken arm by a light splint and by resting it against the chest. For a broken leg, immobilize the fracture with a pillow or a blanket, and a splint.

7. For injuries of the eye, ear or nose, send the patient at once to a physician for treatment.

8. Get a doctor quickly, or if this is impossible, get the patient quickly to a doctor, taking care that he receives no further injury.

9. Do not give a patient whisky or any other liquor. Make him as comfortable as possible and let him alone.

10. It is better to do nothing than to do too much. Nature left to herself will do a lot towards first aid.



Hydro-Electric Development in Eastern States

By D. H. Colcord*

UNDER normal conditions the value of water power for generating electricity is far from being a dead issue. Even where coal is the natural source of power, water power that is contingent to extensive markets, can and will be developed to supplement steam. There are a number of instances where our Eastern rivers afford excellent head-sites within easy transmission distance of manufacturing centers, that if developed on a large scale would be practical from a business standpoint to say nothing of their tremendous benefit to the public by affording cheaper light and power.

In the United States there is about four or five times as much steam as water power in use. The aggregate water horsepower developed and undeveloped is approximately 60,000,000. The Secretary of Agriculture estimates the water power development in 1916 to be 6,500,000. This means that there is still undeveloped water power in this country equal to twice the present steam capacity in service. Approximately 40,000,000 of the undeveloped water horsepower is in 13 of the Western States, leaving about 13,500,000 hp. in the East.

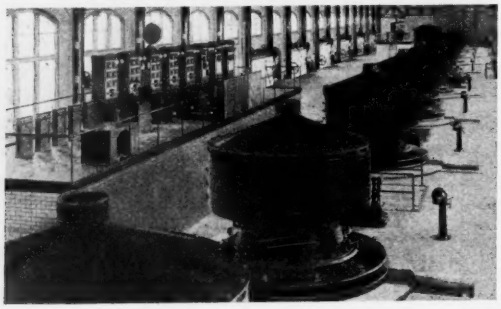


FIG. 1. THE FIRST HYDRO-ELECTRIC PLANT IN AMERICA STARTED IN 1895 AT NIAGARA FALLS, N. Y., AND STILL GOING

It is with the possibilities of developing these 13,500,000 hp. in Eastern United States that this discussion deals. As 32,500,000 hp. is generated by steam and as this steam is generally created from coal—a fuel which is sometime going to be exhausted—and as the greater proportion of steam power is used in the East, where there is always a market for power, the question of numerous small developments here although less romantic than harnessing the tremendous water power potentialities in the Rockies, has certain concrete financial possibilities.

The grand total of all hydro-electric plants, 61 in number, in Pennsylvania in 1916, including auxiliary power units, was 172,872 hp. These plants vary from 8 hp. to the capacity of the largest central station at Holtwood, located on the Susquehanna River and laid out for ten vertical units. Eight units have now been installed. Units six, seven and eight have a normal capacity of 12,000 kv. each. The dam is half a mile in length and is built of solid concrete with an average height of 55 ft. The power generated at 11,000 v. is stepped up to 70,000 v., through three-phase transformers and is transmitted about 40 miles to the city of Baltimore over aluminum cables suspended from steel towers. The development is owned by the Pennsylvania Water and Power Co.

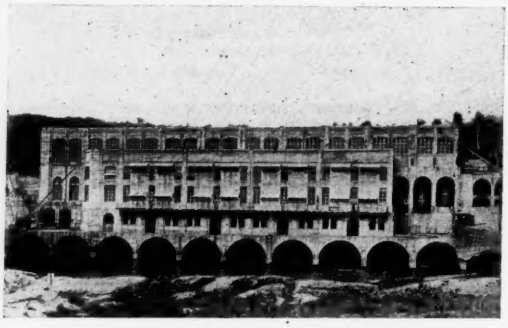


FIG. 2. POWER HOUSE AT HOLTWOOD, PA.

The following table is taken from a report of the New Jersey Water Commission for 1918 and compares the utilization of water power along the Musconetcong River between Hackettstown and Riegelsville for 1894 and 1918. Excepting the Passaic River, the Musconetcong has the greatest hydro-electric facilities in the state.

The table shows an increase of 46 per cent in total horsepower in 24 yr., although the number of mills decreased by two. It proves that hydro-electric power is successful even within easy hauling distance of the coal mines, and means that a singular outlay on other developed streams would not be a mere venture.

*Of the Westinghouse Electric & Manufacturing Co.

Kind of Mills	—1894— H.P.	No. of Mills	—1918— H.P.	No. of Mills
Paper mills	955	3	1610	3
Grist mills	579	10	368	6
Graphite grinding mills	80	1	290	2
Worsted yarn mills	...	..	110	1
Machine knives mills.	75	1	100	1
Saw mills	...	..	40	1
Snuff mills	35	1	....	..
Total 1724		16	2518	14
Total head in ft.. 179			176	

The general advantages desired from a greater development are:

1. The highest use of coal is to create heat to preserve man's life and the term of man's existence may depend on the care of the supply. Fuel is not essentially reproductive. Waterpower for industry can save the nation millions of tons of coal a year.

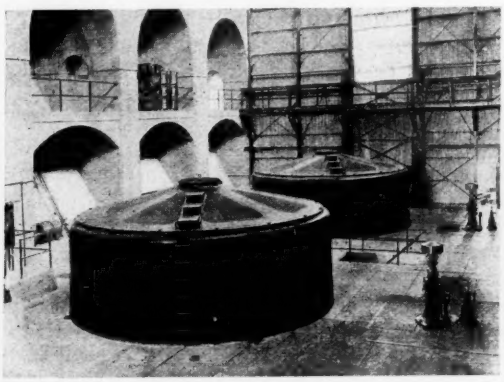


FIG. 3. INTERIOR OF GENERATING STATION AT HOLTWOOD, PA.

2. The East is first and foremost an industrial section and depends primarily on fuel and any effort to conserve it will lengthen productive life.

3. The electrification of all railroads in the United States is inevitable and provision must be made to supply the electric power. As railroads follow the streams the natural source of power is that which is the most available—the stream itself.

4. Water-power makes electric lighting possible wherever it is needed.

5. Where steam power is already used it can well be supplemented by water power.

6. Storage reservoirs used with hydro-electric plants are a protection against floods.

7. During the droughts in summer, the expulsion of water from impounding dams improves sanitary conditions along the stream below.

8. Impounding dams on rivers often improve navigation.

9. The thickly settled districts afford a large market for electric power with reasonable transmission distances.

10. The prevalence of old canals and dam sites makes it possible to install a plant at a small cost.

11. There are many limestone streams in the mountainous districts that have a high rate of flow during the dry seasons.

12. Labor that is released with the close of the war can be used to build the plants.

13. Increased industrial efficiency is effected due to labor saving and waste prevention in distributing power.

From a conservative and absolutely safe standpoint considering immediate returns on the investment, the correct policy in the East is to use water power only to supplement steam and where coal is available at a fair price. But this policy is somewhat pinched and near-sighted from national industrial and economic standpoint, because the time is coming when the available coal will be gone. A nation like ours can afford to dream at least part of the time when every river that runs from the summits of the Appalachian Mountains to the sea will halt from time to time in its wanton course and convert its energy into power that will electrify the Atlantic Seaboard. There may come a time when the coal that is left will be required for purposes that a central station cannot serve such as driving the engines on our ocean liners or as fuel for keeping us warm.

FIG. 4. WATER POWER DEVELOPMENT AT ROCHESTER, N. Y.

At the present time in Eastern United States, hydro-electric possibilities represent another big idea, still vague, indefinite, but so tremendous and colossal that it is food, fit only for the brain of some Titan of Industry like Westinghouse or Edison. Horsepower that runs into millions is being wasted every year as our rivers run wantonly to the sea.

Why isn't it possible for the Geneseo, the Delaware, Susquehanna, the Juniata, Allegheny, Monongahela, Ohio, the Passaic or the Musconetcong Rivers to be harnessed as completely as have been the Huron, the Kalamazoo or the Grand Rivers of Michigan? For example imagine central stations at Lock Haven, Williamsport, Harrisburg, Sunbury, each the size of the complete hydro-electric plant at Manistee, Michigan. They would furnish power for 20 cities and towns, turning the wheels for great silk and paper mills and make it possible to electrify the whole Buffalo-Washington Division of the Pennsylvania Railroad. Multiply in your

imagination, this river by hundreds of other streams, and these cities by thousands of other cities, and the vision appears of a vast network of transmission systems extending from Maine to Florida furnishing every unit of power required from that of preparing the toast for breakfast to that of driving giant locomotives over the Allegheny Mountains. The vision contracts considerably, when you consider that Pittsburgh in 1914 had only 2320 hp. derived from water turbines in the Ohio basin.

In Great Britain proposals have been set forth for vast central station power plants, and stock is being taken of all of the water powers of the British Isles. Since the outbreak of the war the Italian government has proceeded with an active water power policy. In 1917 and 1918 there have been concessions granted for 1,024,000 hp. Norway has developed 1,120,000 hp., and plans to export hydro-electric power to Denmark. Barcelona, in Spain, is replacing steam power by hydro-electricity. In Switzerland 25 per cent of its 2,000,000 hp. available has been developed. A Canadian company has completed a large portion of an extensive system of reservoir and hydro-electric stations on the Nogurea Pallaresa and Segre Rivers. All of these are indicative of the fact that other people are laying a lasting foundation for power for years to come and it is with them that we must compete for the world's trade.

Small Alternating Current Motors

THEIR TROUBLES AND HOW TO REMEDY THEM. BY J. C. HAWKINS.

DURING the past 3 yr. the writer has been called upon to locate trouble in and repair many small a.c. motors used for pumping water, grinding meat and coffee, running small ice machines and numerous other uses which require small power, and which employ motors taking current in most cases from lighting circuits. These motors as a rule range from 1/10 hp. to not over 2 hp., and are constructed along different lines from the large a.c. motors, and in most cases while the cause of the trouble was easy to locate and remedy, in others considerable difficulty was experienced.

These small motors are of two general types, single-phase induction-repulsion machines, which start as a repulsion motor and after attaining speed run as an induction motor, and the split-phase clutch and clutchless type, which uses some form of a short-circuiting switch in starting and which is automatically thrown out after the motor comes up to speed. In many cases they are found to operate on either 110 or 220 v. 60-cycle current.

In one case of a new motor which failed to run at the required speed it was found that the motor was connected up for 220-v. service, whereas the line voltage was only 110. The motor ran at about half speed. Changing the connections cured the trouble. If it had been connected up for 110-v. service and with a line voltage of 220 serious damage to the motor might have resulted. Usually all motors wound for either 110 or 220 v. have four lead wires on the side of the frame for connecting the line. If the motor is to run on 220-v. service the two middle wires should be connected together, while if the line voltage is 110 each of the two middle leads must be connected to the adjacent outside lead.

Direction of rotation of all induction motors of this class can be reversed by shifting the brush holder yoke. The distance that the yoke is shifted to reverse the direction of rotation is slight, and it is necessary to see that the lines on the stationary and movable part coincide exactly if the motor is to run well. In one case, a ½-hp. 220-v. single-phase motor was used to operate a small house pump. At times it would start all right, and again it would not start or would run in the wrong direction. It was located in the top of the well house, inaccessible without removing the motor. This, however, was done, and the trouble found to be that the set screw holding the brush holder yoke was loose, allowing the brushes to shift at will. Sometimes the pump turned the motor backwards slightly after shutting off, which moved the yoke and reversed the direction of rotation or left the brushes in the neutral position.

Brushes sticking in the holders is one of the principal causes of trouble in small a. c. motors. As a rule, it prevents them from starting. The brushes should move freely in the holders, yet closely enough to make good contact. If they do not move freely, they will not make good contact with the commutator in starting, or may not touch the commutator at all, in which case the motor will not start. The trouble is usually due to an accumulation of grease and dust, and the easiest way to get rid of this is to remove the brushes and wash them in gasoline or coal oil. The bottom brushes are as a rule worse than the top ones.

In the usual make of induction-repulsion motor of the commutator type there is a governing device which allows the motor to start as a repulsion machine, and after it has attained full speed, the commutator is short-circuited and the motor runs as a straight induction motor. The governor should pull the brushes off the commutator with a snap as the motor reaches full speed, to prevent sparking. Care should be taken to see that all the brushes are of the same length, and that they make good contact with the commutator, which will not be the case after they have become worn down. The holders should clear the commutator at least ⅛ in. and the brushes about 1/16 in. when the motor is running full speed. The brushes are used only in starting; but if the motor is started frequently, or is overloaded so that it runs as a repulsion motor—that is, if its speed is decreased so that it falls out of step with the line—it has to start all over again, and if this condition continues it may have sparked enough to make the commutator rough, causing excessive sparking and brush wear. In this event it should be smoothed down with No. 0 sandpaper.

In small motors overloading is a frequent cause of trouble, due in most cases to additional friction in the driven machines or even in the motor itself. One of

the worst cases of this kind I ever saw was in a 1/6-hp. 220-v. motor used to drive a small water pump. The outfit had been in use several years with doubtful care, and as the motor was directly over the pump, the bearings had worn down enough so that the rotor rubbed on the stator. This condition had been gradually growing worse, until the motor would not start at all. It required a very careful examination to discover the trouble, as the bearings seemed to be little worn. The rotor was removed and the stator smoothed down with a fine file just enough to clear the rotor, and a new set of bearings ordered from the factory.

One of the surest signs of overload is the failure of the governor to throw the brushes off the commutator as the motor speed increases. It may throw off for a few seconds, or until the speed drops and the rotor falls out of step with the line, and then on again until the speed picks up again, due to the additional torque obtained when running as a repulsion motor. This trouble is, however, at times caused by the condition of the governor. If the motor is not kept clean, the spring barrel ring on the governor may stick, preventing the brushes from working properly, or may not let them down on the commutator when the motor stops, in which case it will not start when the switch is again closed. In some instances where the motor is required to start a heavy load, better working conditions may be had by changing the position of the brushes slightly to give greater starting torque. To increase the starting torque, move the brush holder yoke slightly inside the running marks, but not over 1/16 in. on small motors. This will slightly decrease the starting current. The governor mechanism should be taken out occasionally and cleaned and oiled. The armature of a motor or generator is one of the most convenient places for dust and dirt to lodge upon, and the most difficult to clean.

The principal causes of failure of the governor to act and take the brushes off the commutator, aside from overload, are low voltage and change of frequency. Low voltage may be caused by overloaded transmission lines or trouble at the generating plant, and as the power of an alternating-current motor varies directly as the square of the impressed voltage, the motor would be unable to attain full speed under full load with low voltage. Another cause of failure of the governor may be traced to the frequency, which may be slightly different from that for which the governor was adjusted. The frequency of the circuit governs the speed of an induction motor, and it is not infrequent that current which is supposed to be exactly 60 cycles, for instance, is 5 or 10 per cent faster or slower, due to improper engine regulation. If the motor is disconnected from the load and the governor works properly, it is probable that overload, low voltage or frequency is the trouble. On the other hand, there are times when the governor is seemingly too sensitive; that is, it goes on and off at short intervals. As a rule its failure to work or too frequent working can be cured by adjusting the spring barrel nut to change the tension of the governor springs.

In all induction-repulsion motors there must be some type of a short-circuiting device by means of which the motor starts as a repulsion motor and runs as an induction motor. This in many consists of a set of segments strung on a wire and placed in a recess inside the commutator. If the segments do not make good contact with the commutator bars there will be sparking between the segments and the bars (which in most cases are out of sight) after the governor has acted. If the motor is overloaded, or the governor acts frequently from some other cause, it will be pulled out of step with the line and slow down. This will cause it to start, or attempt to start again, since decreased speed causes the circuit to be broken inside the commutator between the short-circuiting segments and the commutator bars, resulting in pitting and burning that may prevent good contact and cause failure to start.

In one case of an old-style single-phase motor which had seen hard usage, excessive sparking at the brushes developed; in starting, and after running a minute, it stopped. A close examination of all visible parts showed nothing out of order, but it was discovered that the lead from the line to the field coil was hot. Investigation showed that the coil was connected to the line with a coupling having two set screws at each end. These set screws were tight, but after removing the insulation and starting up, the connection became red hot, increasing the resistance to the voltage through the field. The coupling was removed and the connections soldered. Loose line wires in the terminal blocks are often found to be the cause of trouble, but easily located.

The split-phase motors used for starting ordinary loads are of either the clutch or clutchless type. They have no brushes, commutator or other starting device, except that the starting current is automatically cut out of circuit after the motor comes up to speed by means of some form of automatic control placed inside of the motor. These rotors consist essentially of two parts, a barrel carrying the armature windings and clutch, and an inside part consisting of the shaft and clutch drum. In starting, the armature and clutch attain nearly full speed before the clutch operates the clutch ring on the shaft, making it possible to start under an excessive load with low starting current. This type of motor is frequently used on meat grinders and other hard-starting machines. It has little to get out of order except the automatic cutout device through which current passes in starting, which should be kept clean and in proper adjustment. The clutch should be taken out occasionally, cleaned and oiled. As these machines require but little oil, it should be of the best. One case of trouble that developed in a split-phase motor of ¼ hp. was due to one of the coils burning out and grounding on the armature so that any one touching any part of the water pipes received a shock. It was found that the coil was wound with No. 26 silk-covered wire, which we were unable to get at the time. The coil was taken out and the ends located. These were then connected together, cutting out the coil, which had to be replaced to balance the armature. The coil was hand wound, with many turns of wire, so that the only way to locate the connections to the next coil was to take it out. The old coil was then shellacked to hold it solid, and after drying out it ran for some time until a new coil could be wound on.

Another ½-hp. motor of the clutch type, used to run a grinder, had given trouble for a long time, as it would start only when the armature was turned to one position. In this motor there are three metal arms having springs and weighed like a centrifugal governor. These

arms make contact with a three-segment ring when the current is turned on, but fly off as soon as the armature starts to turn. It took some time to locate the fault, which was that one of the arms was slightly longer than the others, and did not make contact properly until it was filed down. In one certain position it worked all right.

Fuse Sizes for Industrial Motors

THE proper size of fuse for a motor is only too often obtained by the chief electrician or one of his repairmen by haphazard methods. The motor's normal operating current is given by the maker on the name-plate, but fuses are properly selected of a larger capacity to allow for starting and for momentary overloads. Hence it is rather more usual for the maintenance man to select his fuses "be guess and be gosh," with a view to their permanence in service rather than the safety of the motor they are supposed to protect.

In order to give a practical working idea of what sizes to use, the Westinghouse engineers have prepared the following tables. These are based on the following assumptions as to size of fuse required to stand starting current without blowing:

Type	Times Fuse Load Current at Starting
Polyphase Wound Rotor	1¼
Squirrel Cage (thrown on line)	3
Single-Phase Repulsion Induction with Rheostat	2
Single-Phase Repulsion Induction without Rheostat	4
Direct Current	1¼

Since the fuses for squirrel-cage and repulsion motors without rheostats are, respectively, rated at 3 and 4 times full load current, they give practically no overload protection. Hence it is recommended that double-throw switches be installed connecting the motor through fuses of 1.25 times full load rating (as under Wound Rotor sizes) for running and through the regular heavier fuses or direct to the line for starting.

FUSE RATING (AMP.) FOR DIRECT-CURRENT MOTORS

	Voltage				Voltage		
Hp.	115	230	550	Hp.	115	230	550
1	10	5	3	12½	110	60	25
1½	15	8	3	15	125	70	30
2	20	10	5	20	175	90	35
2½	25	12	6	25	225	110	45
3	30	15	6	30	275	125	55
3½	35	15	6	35	325	150	65
5	50	25	10	40	350	175	75
6½	65	35	15	50	450	225	95
7½	70	35	15	60	550		110
8½	85	45	20	75			150
10	90	45	20	100			200
11	100	55	25				

FUSE RATING (AMP.) WOUND ROTOR INDUCTION MOTORS

Voltage:	3-Phase			2-Phase	
Hp.	220	440	550	220	440
5	20	10	8	20	8
7½	30	15	12	25	15
10	40	20	15	35	20
15	50	25	20	45	25
20	70	35	30	60	30
25	85	40	35	70	35
30	100	50	40	90	45
35	125	60	50	110	55
40	150	70	60	120	60
50	175	80	65	150	70

FUSE RATING (AMP.) SQUIRREL CAGE MOTORS

Voltage:	3-Phase				2-Phase		
Hp.	110	220	440	550	110	220	440
½	12	6	3	2	10	6	3
1	20	10	5	4	20	10	5
2	35	20	10	8	35	15	10
3	50	30	15	12	45	25	15
5	90	45	25	20	80	40	20

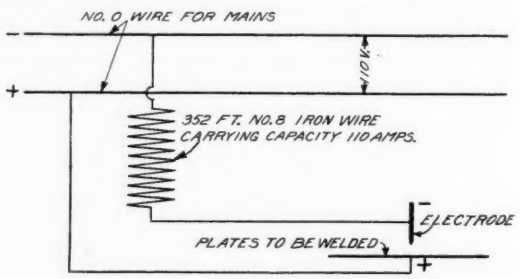
FUSE RATING (AMP.) TYPE AR SINGLE-PHASE MOTORS

Voltage:	Without Rheostat		With Rheostat	
Hp.	110	220	110	220
2	80	40	40	20
3	120	60	60	30
5	200	100	100	55
7½	325	175	175	80
10	400	200	200	100
½	20	10	10	6
¾	30	15	15	8
1	40	20	20	10

Arc Welder for the Power Plant

HANDY HOMEMADE WELDING OUTFIT TO BE USED FOR REPAIRING TOOLS AND MINOR REPAIRS ABOUT A POWER PLANT

ELECTRIC arc welding is at the present day in a stage where it can be successfully applied to a number of cases, such as welding boiler tubes to tube sheet, welding patches to boilers, stay bolt heads, flanges to pipes, branches to pipes, building up worn parts and repairing broken tools such as stilson and monkey wrenches, etc.



CONNECTIONS OF HOMEMADE WELDING OUTFIT

In any plant where direct current is available, the engineer may rig up a homemade welding outfit and make quite a few repairs; this outfit, however, may not give as satisfactory results as a regular welding outfit, therefore a regular welding set must be used wherever possible.

Take 352 ft. of No. 8 iron wire and wind around an asbestos core about 4 or 5 in. in diameter, bringing the ends out on the opposite sides of one end of the core and making suitable ends for attaching wires to. This rheostat will be capable of taking care of 110 amp. Next connect the positive side of the line to the metal to be worked, and the negative side to the electrode, with the rheostat in series.

Having the outfit properly connected, the metal to be welded is thoroughly cleaned and prepared. A welding compound is sometimes needed to make good joints, which can be bought from some concern manufacturing welding material. With the use of regular welding electrodes, this welding compound is often not needed, because the electrode itself is the adding material, and the core contains welding flux.

Checking Up Alinement

DETAILS OF PROCEDURE FOR A CROSS-COMPOUND ENGINE. BY GEORGE H. WALLACE

IN checking up a cross-compound engine, one must have ample time in order to make a satisfactory job of it; by that I mean that this kind of a job cannot be done "between two days" nor on Sunday.

The engine should be shut down long enough to get cold, and every assurance must be had that the engine is not influenced by steam or exhaust piping. The writer once found a compound engine in which the exhaust pipe was anchored to the steel framework and the heavy braces tightened while the pipe was hot. When it cooled, the influence of the contracting exhaust pipe was enough to draw the cylinder out of alinement.

The piston rods and connecting rods should be removed, and the crosshead also, if the piston rod hole does not run through it.

The first thing to do is to check the level of the shaft, usually done best by leveling on top of the shaft in the main bearings, taking care that the shaft is not worn so as to prevent accurate work with the level. Unless the shaft is unusually large or quite short, the weight of the flywheel and generator (or belt wheel, as the case might be) will cause the shaft to sag a small amount.

If the revolving parts are situated about equally between the two bearings, the effect of this sag will show up on the level about equally on each end. Sometimes on a direct-connected outfit the weight will be a little nearer one end of the shaft, in which case that end will show the greater amount of sag.

For leveling, use a good instrument, one known to be absolutely accurate. The writer was called upon once to tear down and re-erect an engine that the shop handy man had set up, using an old mason's level much the worse for wear.

A 12 or 18-in. graduated, ground glass level is an ideal instrument, as it will show a difference in level of less than a thousandth part of an inch. A thickness gage or "feeler" can be used under one end of the instrument to measure the difference in level, working on the basis of so many thousandths of an inch difference in level per foot.

If there is any evidence that the shaft is out of level, the method used to correct the evil will depend on the construction of the engine. If the fault is due to one (or both) bearings having heated to the running point at some time, or if the difference is due simply to ordinary wear, rebabbiting is the only remedy.

If the lower part of the main bearing is a part of the main frame (as is sometimes found in the older types of cheaper engines) rebabbiting is the only remedy, as is also the case if the bearing is of the "four-piece type," with the lower shell bored concentric with the shaft.

If, however, the lower part is in two pieces, the inner one of which is bored and turned concentric with the shaft, any difference in level can be corrected by placing good steel shims under the outer piece where it rests in the frame.

If the bearings have been allowed very much movement, or if the revolving parts are out of balance (which is the case oftener than the average engineer suspects) it often happens that this constant but small movement of the bearing on its frame base will mean considerable, in which case planing or shaping off the rough parts is necessary. If planing the frame is not feasible, inserting a flat piece of cold rolled or other dimension steel equal to what was planed off the bottom of the bearing is a good way out of the case.

Another way of leveling the shaft, provided that the wheel runs true, is to drop a plumb line beside the wheel a given distance (say, 1 in.) from the edge, and close measurement at the bottom of the wheel will show any difference in the level of the shaft.

To stretch lines through cylinders for the purposes of alinement, they must be attached to targets that are absolutely rigid and yet permit a small adjustment of the lines.

The target at the back end of the cylinder can be bolted rigidly to one of the cylinder head studs. The one beyond the main bearing should be of the bracket type and weighed with pig iron, bars of iron or any such material.

Make the tram sticks out of straight-grained white pine, basswood, cedar or any other such light wood, and drive pins in the ends till the trams are approximately right.

Set the line by the counterbore of the cylinder (if diameter permits), otherwise by the back counterbore, the stuffing box and the guide, in which you will generally find four "side spots" which are bored with the slide for the purpose of lining up.

If the engine was properly machined and erected the cylinder and slide ought to be in line; if they are not a "happy medium" should be arrived at so as to check one side of the engine against the other.

In placing the targets, they should be arranged so as to permit measuring across from line to line, both at the back and front ends.

Having accurately adjusted the lines so that they are absolutely central in their respective sides, the next thing to do is to see if they are parallel, which is done by measuring from line to line with a steel tape laid on the edge of a light board (to prevent sag), or if a steel tape is not at hand, the dressed edge of a board will be all right, as the distance can be scratched on the board at one end, with a knife point, and if it is the same at the other end, the two sides of the engine are parallel; if there is a slight difference it can be measured on the board with a small scale.

Now, the shaft may be level, and the two sides parallel and level, and all that, yet the shaft may be out of square with the lines. To check this up, measure from the line to the edge of the crank disk, front and rear, and if the shaft is out of square, the tram and thickness gage will show the amount.

Here again one must know local conditions to prescribe the remedy. If one side of the engine has been set too far forward or back when the engine was first erected, that can't be changed, as the grouting has fixed the location; however, if the bearings have wedges

front and rear, or even only on one side, any difference can be remedied by adjusting wedges front and rear, or by shimming under one or the other of the "cheek pieces," as the case may require.

An engine, like an old shoe, naturally assumes a certain easy, comfortable shape in the relation of its several parts to one another, and when this close relation is disturbed the original conditions never can be restored. Have a new sole or heel put on your shoe, and note how changed your gait is; just so with an engine. Bearings wear into a certain relation; the piston and steam ring have a well-worn path in the cylinder, as does the rod in the packing, soft or metallic, and when this relation is changed great care must be used to insure smooth working conditions. The main bearings, crankpins, etc., may require scraping, and in any event the engine must be watched closely until the "comfortable shape" has again been restored. A little thought will usually find the right way to do things at the right time.

Power Plant Engineering for Handicapped Men

OPPORTUNITIES OPEN FOR VOCATIONAL EDUCATION TO MAIMED POWER PLANT MEN. BY HENRY BRAXTON*

THE CALL for power plant employes is increasing, and it is work that is suitable for soldiers or sailors with various degrees of handicaps, as well as for the able bodied. The United States is ready to help train men in this growing industry if they are willing to give the time necessary for a proper training and are eligible.

The Federal Board for Vocational Education has divided the country into many districts, where offices are maintained and any man in the neighborhood should apply for information. The Board has recently issued an "Opportunity Monograph" (Vocational Rehabilitation Series No. 14), entitled "Electrical Employment with Utility Companies," covering information upon Electric Light and Power Companies, Electric Railway Companies, Telephone Companies and Steam Railroads, and this may be had for the asking.

FIG. 1. MAIMED WORKMEN IN AN ELECTRICAL WORKSHOP IN ROEHAMPTON

If a man wants a special technical training, efforts are made to put him in the best school that teaches this trade, his tuition will be paid and he will receive the compensation for his disability or his military pay, whichever is the greater, for the period of his instruction. The Federal Board uses existing schools as far as possible, and has arranged with some manufacturing and commercial establishments for a modified form of apprenticeship, by which a man may receive his technical training by spending part of the time in a school and by doing actual work in the industry which he has selected. Several of the Federal Board schools are equipped to provide training of this character. Many a man may thus have an opportunity to finish an interrupted education or go further than he had expected before he became a soldier.

The Red Cross Institute, at 311 Fourth Avenue, in New York City, is not equipped to help in this particular field, but offers short, intensive courses in seven practical subjects—oxy-acetylene welding, motion picture operating, mechanical drafting, jewelry making, printing, typewriter repairing and making of artificial limbs—which are open to civilian cripples and such soldiers and sailors as the Federal Board sends for instruction in these trades.

The employment bureau of the institute has been able to place a number of men with leg amputations in power house positions, where they have made good. These men, of course, had had previous experience in this sort of work, and did not need retraining, but only help in readapting themselves to their handicapped condition. Several men with but one arm have gone through the employment department, and one in particular has shown that the loss of a hand or arm could not keep him from being a more than satisfactory engineer, when once the opportunity was secured to let him prove himself.

This man met with the accident which cost him his left arm in a boat where he was serving as engineer, and in spite of having had experience as chief engineer of a power station, and knowing enough of boiler inspection to have secured a license, he could not find work, no one being willing to engage him in such a handicapped condition. He was in a most discouraged state of mind when he sought the services of the Red Cross Institute. An engineer was wanted in an out-of-town power plant, and there he went, quickly showed that he could do as good work as before his loss, and has written contented letters telling of his promotion to be chief engineer in charge of other employes, and that he was able to save a goodly sum to his employer by economical running of the plant.

In work that is somewhat similar to power plant engineering, it has been found that men with one leg amputations can do well in mechanical operations and have resumed many forms of electric work, as well as

* The author is connected with the Department of Education of the American Red Cross and in this article, prepared especially for readers of Power Plant Engineering, tells of the work being done in this and foreign countries to fit crippled men for special work in the power plant.

oxy-acetylene welding, etc. Those with both legs gone have to specialize still more, but can take up polishing, become inspectors and testors of electric apparatus, coil winders and assemblers of small machines. In England, France and Canada a few one-legged men have worked as firemen of boilers, which they had been accustomed to do before losing their legs, but it would be better for the average man to choose running the engine or operating the mechanical stoker.

Such work as oiling, operating a switchboard, lathe, hand soldering, using a drill press and learning to be draftsmen, are within the possibilities for one-armed men. The American Society of Mechanical Engineers points out the need of adapting methods and devices to the cripple and the need of assisting him to adapt himself to existing devices. A little ingenuity and sympathetic thought in arranging auxiliary controls and attachments would be the best means of showing one's gratitude to the maimed soldier and helping him at the same time to make the most of himself as an able and independent workman.

This is the way the United States is prepared to take care of its soldiers. It may be profitable to see what other countries have done that have had the problems of handicapped men longer in mind. Several years ago, in England, the Ministry of Pensions, co-operating with the Ministry of Labor, appointed Trade Advisory Committees for most of the principal trades, these committees being composed of an equal number of employers and work people. Their purpose was to advise as to the best conditions for training in a given trade, where training of a proper standard could be had, and later a number of these local committees combined to use the facilities for technical education in whole counties or groups of counties.

Most of the training in electrical work has been provided in London. There a class was started to train men as electric sub-station attendants, which demanded a minimum of training of four weeks. The course consisted in A—Workshop practice in wiring work and the use of simple tools. B—Power house demonstrations to familiarize the students with switching gear and running machinery. C—Electrical and physical laboratory work. D—Class demonstrations in the elements of electrical engineering and of simple engineering physics. E—Writing of reports upon the demonstrations and laboratory work, and F—An oral examination at the end of the course.

Fifty men with limb amputations who had been training in the workshops of the military hospital at Roehampton had received further instruction in electrical and mechanical engineering, lasting a month or six weeks at a polytechnic school, and all were easily placed in good positions. Another course in electrical engineering for small plants lasted three months. It was found that short, intensive courses in special classes were the best means of training the adult, as grown men are sensitive about being in classes with youths and impatient to get out of discipline and back at work, and special classes gave opportunity for individual attention to the various degrees of handicaps and the best ways to surmount them.

After several years' trial of short courses, a report was made in 1918 "Upon Openings in Industry Suitable for Disabled Sailors and Soldiers"—No. XX considers Electricity, Power and Light. A detailed study was made of all the processes suitable for disabled men, and these were classified into sections as follows:

1. MINOR OPERATIONS.
   - 1—Sub-station and Switchboard attendant.
   - 2—Generation: a, Driver (Turbo and Dynamo); b, Dynamo Attendant.
   - 3—Country House Plant Attendant.
   - 4—Storekeeper.
2. SKILLED TRADES.
   - 1—Engineering side: a, Electrical Fitter, Electrician and Controller Repairer; b, Armature Winder; c, Meter Repairer.
   - 2—Contracting: Installation, Maintenance and Repair.

Then the various processes were analyzed from the point of view of the handicapped man, and whether it was a minor operation or a skilled trade. For example: Generation (Driver-Turbo and Dynamo): The man must be able to stand at his work, but the use of an artificial leg would not debar him from this occupation, provided he is able to move about freely. The use of both hands is necessary, but the loss of one or two fingers on either hand would not exclude the man, nor would the loss of an eye. The work is carried on under cover and in an equable temperature, and men suffering from chest complaints might in some cases be employed. Shell shock cases, however, should be excluded.

FIG. 2. WORKMEN WHO HAVE UNDERGONE LEG AMPUTATIONS MAKING MAGNETOS IN LORD ROBERTS' WORKSHOP

The period of training for country house plant attendant and for storekeeper is 6 mo.; that for the other operations is 52 weeks, the first 13 weeks to be spent in a technical school and the remaining 39 weeks to be spent in all cases in factory or shop. For the skilled trade a man must be prepared to give 3 yr., the first 6 mo. to be spent in a technical school and the remaining time in a factory or workshop. When the man goes into a factory he is practically an apprentice and begins to receive a small wage from the employer, which is increased as he becomes more skilled.

In Canada the period of training at Quebec for electric power plant engineer is 3 mo.; at Toronto it is 6 mo. for electric sub-station or power plant worker.

At Halifax, Kingston and Calgary a man may take a course in several kinds of electrical engineering. The relations of the vocational officers with the representatives of organized labor are most intimate and cordial, the labor men having been helpful in advising as to essential features of instruction and in other ways. The decision whether or not to take training is optional on the part of the soldier.

While there are over a hundred re-educational schools in France, none offer instruction in power plant engineering. However, in the large school for watch making at Cluses a two years' course has been arranged for wounded men, which includes "electricity." There it was found that most of the "reformes" had been wounded in the leg, only a few in the arms or hands, but even these have done well since no great strength is required for operating the power-driven machinery or manipulating tools, and an artificial leg can work a clutch pedal as well as a real one. An eight months' course in radio telegraphy is thorough and practical. In France it has been found that 65 to 75 per cent of the maimed men come from the agricultural districts, and when unable to resume their farm work have chosen small trades, such as cobbling or basket making, that are always useful in villages.

Re-education for Belgian war cripples is compulsory, and this was accepted more readily because the majority of the soldiers had no homes to go to. Two large schools for vocational re-education were maintained by Belgians in France. The famous one at Port Villez conducts classes in over 40 trades, among them one for electricians, the requirements being an ability to climb ladders and string wires. The Minister of War organized the Home University, which provides opportunities for study in Paris, and here a number of Belgians have taken advanced work in electricity.

Re-education in Germany begins in the hospitals, many of which maintain workshops to which the men are sent as soon as they are able to be out of bed. An outdoor plan is to send the men to local trade schools, and courses in electric work are no doubt provided with the usual German thoroughness.

Economical Ammonia Compression

STOP THE LEAKS. REGULATE THE PRESSURES. CLEAN UP. BY A. G. SOLOMON

IN THE operation of refrigerating machinery it is the engineer's objective to attain the point of greatest economy. This striving for the best results at the lowest possible cost has become more necessary since conservation of ammonia, fuel, oil and all other material is demanded.

Fuel is the principal item when economical operation is considered. Save fuel in every way in which it can be saved.

To sum up the whole matter:

STOP THE LEAKS

REPAIRING the visible leaks in the steam piping is an easy matter and therefore not often neglected. It is the invisible leaks that must be located and prevented. More fuel than is necessary must not be used to perform a certain amount of work.

When most engineers are brought face to face with the fact that too much steam is being used and no leakage is visible, they grab their indicating outfit and proceed to take cards and adjust the valve setting of the steam engine which drives the ammonia compressor. This is a good thing to do, but it is not carried far enough. Usually the diagrams are closely examined and the slightest defect in the valve setting is remedied.

Now the question comes up whether the engine is required to consume this amount of steam while turning out the tons of refrigeration produced.

We will take it for granted that the steam distribution at the steam cylinder is all that can be desired and also that there is no preventable loss of fuel in the generation of the steam nor loss between the boiler and the engine.

This will lead us to consider next the load that is being carried.

To all outward appearance, the ammonia may be handled properly and with economy when condenser and suction pressures and temperatures are consulted.

But is the ammonia compressor doing its full duty?

VALVES AND CAGES

INSPECT every part of the compressor for leakage that will allow vapor to be compressed more than once. If a suction valve leaks, ammonia gas is discharged back into the suction line from the compressor and this same gas is again taken into the compressor when the piston moves on the suction stroke. A leaking discharge valve allows hot compressed gas to flow back into the compressor and not only results in the double amount of work being expended in the second compression but also takes up space in the compressor to the exclusion of the vapor from the evaporator.

Defective gaskets or ground joints under the valve cages will have the same wasteful results as leaking valves. Leakage through the seating surface of a safety head on Frick and York compressors is the same in effect as a leaking discharge valve.

Large clearance space between the piston and the compressor head is also detrimental to economy, as the hot high-pressure gas contained in the clearance space will exert pressure during part of the suction stroke and by so doing prevent the suction valve opening as soon as it should.

Now it is evident that allowing ammonia to leak by a valve or valve cage is a sure way of using a greater amount of power than is necessary and by doing so fuel is wasted.

Grind all valves to their seats till the joint is so perfect that gasoline will not leak through. This gasoline test is the most reliable that can be used. If the cages are ground in, be sure that this point of contact is also as perfect as very fine emery can make it. Do not call any ground joint good enough till it will hold gasoline.

If gaskets are used under the valve cages, see to it that they are of the proper material and also that they

fit properly. Sheet lead is the most satisfactory material to use under valve cages.

Careful inspection of the valves, cages and gaskets will almost always be the only precaution necessary to locate leakage.

Cylinder Leakage

Leakage of the ammonia gas from one side of the piston to the other is generally hard to be sure of. The cylinder must be accurately calipered at all points throughout its length to determine whether it is out of round or if one part has worn larger in diameter than the true bore. Scored or cut places will, of course, allow leakage.

The piston rings must be a proper and snug fit in the grooves and must have sufficient tension to press out against the cylinder walls.

So far the hunt for leakage has been entirely by close inspection of the different parts. Still there may be leakage which can only be found by the use of the indicator. A diagram taken from an ammonia compressor will show the actual working conditions. But simply looking at a diagram is not sufficient. A card may be perfect looking even to a close observer and yet the compressor may be in bad shape.

By this I mean that what we may term a good looking card does not necessarily mean that the compressor is in first class condition.

There is only one sure way of deriving any benefit from the penciled lines on the card, and that is by plotting the adiabatic line or curve. The relation or position of the compression line drawn by the indicator and the line that represents the adiabatic compression of the ammonia is the only guide we have as to what is really going on in the compressor. This article cannot give the instructions for plotting this curve, but there are several books published in which will be found the necessary information.

Any engineer fortunate enough to have an indicator which he can use surely should become familiar with the different lines that make the diagram worth the time spent in its taking.

Recompression of the gas can also occur by leakage from the cylinder to the suction line by way of the oil lantern and gas relief line. See that the rod packing between the bottom of the stuffing box and the oil lantern is in the best condition possible.

We all know that when figuring the horsepower of a steam cylinder it is first necessary to find the mean effective pressure of the steam and to do this the area of the indicator diagram must be measured. Figuring the horsepower of an ammonia compressor is no different from figuring the horsepower of the steam cylinder. Measure the area of the diagram by means of a planimeter or by the use of ordinates and so find what the mean effective pressure is. Then proceed the same as if it were a steam cylinder; but do not neglect to take into consideration whether the compressor is single or double acting.

Ammonia Temperatures

When we have proven to our satisfaction that the ammonia compressor is in as perfect condition as possible, the next step in economical operation is to see that the temperature of the ammonia is right in the different parts of the system.

At three points thermometers should be inserted and regular readings taken. These places are, in the liquid line close to the expansion valves, in the suction line close to the compressor and in the discharge line close to the compressor.

As pressure and temperature of saturated ammonia vapor are functions of each other we should try to keep the relation as close as possible depending on the conditions of the individual plant.

The liquid ammonia going to the expansion valves should have a temperature not more than 2 or 3 deg. higher than the cooling water. This is not difficult to maintain where double pipe condensers are used, if the pipe surfaces are kept clean by frequent washing and brushing.

Where the atmospheric type condenser is used, the cooling water will be somewhat heated in its passage down over the coils. The installation of a liquid precooler or a water jacket around the liquid line will prove a money saver, as the liquid temperature can thus be lowered and this reduction will allow every pound of ammonia to absorb more heat units from the brine or produce.

Part of the liquid ammonia which enters the evaporator is vaporized in withdrawing heat from itself. The liquid has to be lowered to the temperature of the brine or air surrounding the evaporating coils before heat can be removed from the substance to be cooled.

The heat laden gas which has received its load from the warm liquid must be handled by the compressor just the same as the gas which is carrying heat which it is desired to remove. By this we see that every degree that the liquid temperature is lowered means in reality increasing of the volume of gas which the compressor handles in doing useful work.

So the thermometer which shows the temperature of the liquid ammonia entering the evaporator can be made the direct means of fuel economy.

An insufficient charge of ammonia will cause the gas to travel too fast, so that condensation will not be complete and the result will be a warm liquid line. Maintain a liquid seal of at least 3 in. in the liquid receiver and the liquid temperature will be about right.

Compressor Capacity

Capacity of an ammonia compressor is usually rated in figures representing displacement.

The volume of gas discharged to the condenser is really only the key to the work performed.

While the pressures remain constant, the number of cubic feet of gas entering and leaving the compressor will also remain the same.

The actual amount of heat sent to the condenser is based on the weight of the vapor handled by the compressor. The greater the degree of superheat of the vapor entering the compressor, the lighter will be the gas and therefore the actual heat load carried from the evaporator will be less.

Then the closer the vapor is to the temperature of saturation, the greater the weight of ammonia handled and also the greater the true displacement of the compressor.

To maintain as close a relation as possible between the suction pressure and temperature, a thermometer

must be inserted in the suction line close to the compressor. By taking hourly readings of the suction pressure and temperature and noting conditions and results as to the work being done, a certain temperature of suction vapor will be decided on as that at which the best results are obtained at the lowest cost.

Even when the suction vapor is saturated just before entering the compressor, it assumes a superheated state upon its passage through the inlet valve. This change of state is caused by the vapor coming in contact with the metal of the cylinder walls, valves and piston which have a high temperature owing to the inability of the jacket water to remove all the heat of compression.

This heating of the suction vapor is a point not often taken into consideration when the capacity of a compressor is figured. Often an engineer is misled as to the actual performance of the machine by taking it for granted that the cylinder fills with vapor of the weight which corresponds with the temperature of saturated ammonia at suction pressure.

The thermometer on the suction line is also a very dependable indicator to let the engineer know when a suction valve becomes defective. Gas escaping back into the suction through a leaking valve or blown gasket under a valve cage will cause a rise in temperature of the vapor. This heating of the vapor in the suction line will be noticeable on the thermometer, but if there is no thermometer, the leakage may continue for a long time without being discovered.

The thermometer in the discharge line is not so important or necessary as those in the liquid and suction lines. As a rule, if the suction temperature is kept close to the saturation temperature, the discharge temperature will be right. But, if the suction vapor is sent to the compressor in too heavily a saturated state, the discharge temperature will show it when no other means of knowing would be available.

After the temperature of saturation is reached, a greater degree of saturation will not lower the temperature of the suction vapor, but it will lower the discharge temperature. All refrigerating engineers know that an ice machine does its best work when the discharge is at a certain temperature and when this temperature is known, it should be kept to that point as closely as possible.

Expansion Valve Regulation

The frost line on the suction or on the ammonia compressor is usually taken as an indicator to guide the engineer in the handling of the expansion valves. This is, as a rule, a good practice, but it is often a mistake to depend too much on it. If the plant is small and but one ice tank or brine cooler is connected to the machine, the frost line will tell how the ammonia is coming over. But when more than one evaporator is connected, the vapor from any one of several can keep the frost line at the desired point by having its expansion valve open far enough to saturate the vapor heavily.

When taking the position of the frost line as a guide, the suction line from each evaporator must also be watched to see that one does not contain superheated gas while the others are carrying vapor sufficiently saturated to overcome the superheat of the evaporator that is not delivering its share. When there are several ice tanks, direct expansion coils or other evaporators connected into one main suction line it is advisable to have a thermometer in each of the branch suction lines.

Oil Traps

Neglect of proper care of the different oil traps in the ammonia system is a prevention of economical operation. If the drawing off of the oil is not done regularly, the inner surfaces of the entire system become coated. A coating of oil in the coils of an ice tank can very easily be likened to the coating of scale on the tubes and shell of a boiler. It acts as an insulation and prevents the rapid passage of heat from the brine on the outside to the ammonia on the inside of the coil; and when we consider the very small difference between the temperatures of the brine and the ammonia, we shall realize that even the smallest amount of insulating effect is very harmful. This temperature difference is usually only between 10 and 15 deg.

The best way to take care of the oil from the traps is to have a receiver connected with the blowoff valves of the different traps and another line connected from this receiver to the suction side of the system. Blow the oil into the receiver and then open the valve to the suction just enough to allow the ammonia gas to escape. The receiver should not be emptied right after it has been filled, as, if this is done, there will be some slight loss of ammonia. Allow the oil to lie in the receiver several hours and the temperature of the atmosphere of the room will evaporate and return to the suction all ammonia contained in the oil.

By watching the traps and preventing oil getting into the system, the steaming out of the different coils will be necessary only about once every 5 yr. Neglect of the oil traps may result in the yearly steaming of coils. Of course, the internal cleaning of the pipe work is a good thing, but it is also costly.

Remember always that the cost of the winter's cleaning and overhauling must be counted in when the economical operation of the plant is considered. There is no saving by operating at little expense during the summer, if by so doing the expense is made heavy during the winter. Look ahead and plan so that such preventive measures are practiced as will keep the cost of overhauling as low as possible.

Ammonia Wastage

Economy in the use of ammonia is one of the most important duties of the whole crew of a refrigerating plant. Ammonia does not burn up as we so often hear. If the temperature of the ammonia in the system ever reached the point where disintegration takes place, I am sure that the plant where it happened would need many new parts as well as a new charge of ammonia. This temperature, which is about 900 deg., is never reached in operation.

By allowing impurities such as oil, moisture and air to mix with the pure ammonia, decomposition does take place and loss occurs as the resultant non-condensible gases must be purged.

So we see that when ammonia in large quantities has to be added, there must be leakage.

Ammonia escaping at the packing of the piston rod and from flanged joints is quickly detected and can

easily be stopped. Such visible leaks need not be discussed as no engineer will allow ammonia to be lost in such a plainly seen way.

Invisible leakage is what we must guard against. The double-pipe condenser is the place where large amounts of ammonia can be lost and the leak not easily located. It is not much trouble to shut off both inlet and outlet water valves on a double-pipe condenser coil and after a few minutes test a sample of the imprisoned water with litmus paper. With even a small leak, water standing in the inner tubes for a short time will become strong with ammonia and the litmus paper test will detect it. This testing should be done at least once a week and more often, if there is any suspicion of ammonia loss.

When new inner tubes are to be put in a double-pipe condenser or in any other double-pipe arrangement the new tubes should be tested before using, with not less than 100 lb. air pressure while submerged in about 6 in. of water. This test will show the very smallest defect in the pipe and will save ammonia and future trouble.

The brine in ice tanks should be tested once a day with litmus paper, as a leak may occur at any time and a large amount of ammonia lost before the leak is noticed in any other way.

Test all places where ammonia coils are submerged under brine, water or other liquid, and test often and regularly.

Leakage often happens in joints under the water in the jackets which surround the compressors. Drain and test with a sulphur stick. And do not neglect to fix the small leaks as soon as it is possible to do so.

Industries in Poland

A Brief Review of Past Conditions and Further Prospects for Power Plant Requirements. From Data Furnished by George Fudakowski

POLAND has been in the main an agricultural community, and immediate future development will probably be in that direction. But her industries, before the war, were thriving and growing rapidly, and with some assistance in the way of capital, will recover rapidly. As equipment and machinery has been almost entirely carried away by the Germans, plants must be rebuilt and equipped, which will offer a considerable field for trade in electrical and transmission machinery.

In 1910, the last year for which there are any adequate figures, the value of manufactured products was $977,200,000, and the number of workmen employed about 900,000. In Russian Poland and other Polish territory under Russian rule there were 8182 plants, using 532,082 hp., of which 1424 plants, with 67,037 hp., were in Warsaw and vicinity and 1241 plants, with 205,951 hp. in the coal region around Lodz.

Warsaw, with 34 per cent of the Polish industries, produces mostly machinery and metal manufactures, while the mills of Lodz, 50 per cent of Polish industries, are largely for manufacturing cotton and woolen goods.

Coal used in Russian Poland in 1912 was 5,390,000 T. of anthracite and 114,200 T. of bituminous, the fields from which it comes being near the junction of the three old empires of Austria, Germany and Russia, in Galicia, Silesia and the western corner of Russian Poland. In fact, the chief coal reserve of the old German empire was in the Polish territory. The field covers 2048 sq. mi. and contains some 94.3 billion tons, of which 61 per cent is in Silesia, 34 per cent in Galicia and 5 per cent in Russian Poland. Only that in Silesia is suitable for making coke, hence is the main source of the supply for the Warsaw region.

In 1911 Silesia mined 43,800,000 T. of coal, one-fourth of that produced in Germany, while Galicia furnished 6,468,000 T. and Russian Poland 1,900,000 T.

Outside Warsaw and Lodz, the plants are for the most part of small size, two-thirds of them employing 50 men or less each, while only 2 per cent employ from 500 to 1000 men. The power used is also small, the 2607 plants in Galicia using only 139,344 hp. There are, however, many plants of small power which use a good deal of machinery, the flour mills, for instance, of which there were 339 using 20 hp. or over apiece.

Galicia has also a considerable mining industry, which calls for the use of power. At Kalusz there are potassium mines which in 1911 yielded 15,000 T., the deposit being in a bed 35 ft. thick, and one of the most important in the world. Iron ore was produced from only one mine, although there are considerable quantities of ore, but zinc was mined to the extent of 591,000 T., lead to 64,427 T. and sulphur 18,200 T.

Silesia and Poland proper also have some mines, the iron product in 1911 being 233,800 T. for Silesia and 258,000 T. for Poland.

Galicia, a land of mountains, has a considerable available water power, though the streams are for the most part small. It is estimated that the total available is 89,400 hp., of which 35,000 hp. is now utilized.

Perhaps the most valuable resource of Galicia is the oil wells, found at the eastern foot of the Carpathian Mts., in a region 240 mi. in length. In 1912 the output was 1,168,371 T. from 1556 wells, and 269 more wells were in process of drilling. This oil is of fine quality, yielding 50 per cent illuminating oil, 10 per cent benzine, 6 per cent paraffine and 25 per cent lubricants.

Formerly only 40 per cent was refined in Polish territory, but in the new development this should be altered so that practically all of it is refined near the wells. With the industry properly established, 75 per cent of the product should be available for export from Poland, and the supply should be sufficient for the wants of 100,000,000 people.

Most immediate of Poland's needs, in order that both manufacturing and agriculture may be developed, is an adequate railroad system. Prussian Poland has a good development, 15.7 mi. per 100 sq. mi. and 8.3 mi. per 10,000 population; but in the Russian and Austrian territories the figures are 8.4 and 4 mi. per 100 sq. mi. and 3, and 1.7 mi. per 10,000 inhabitants, respectively. These figures, compared with those of other countries, show that the railroad facilities should be at least doubled for adequate service in Russian Poland.

The first group of lines planned for connecting the

mining regions of the western section with the manufacturing districts to the north and east comprise 1144 mi. and call for 700 locomotives, 19,000 freight cars and 600 passenger cars. Besides this, the present lines have been stripped of rolling stock by the Germans, so that to supply them there are needed 1400 locomotives, 39,200 freight cars and 1100 passenger cars.

For the second group of railroads to connect the Posen section and Silesia with eastern Poland the mileage needed is 838, and the equipment to operate, 500 locomotives, 14,000 freight cars and 430 passenger cars.

Besides rails, ties and other track material, there will be needed equipment for telephone and telegraph lines, water supply, repair shops and buildings for employes. So that the total will run to a considerable figure.

As to power transmission, the industrial center of Warsaw is 180 mi. from the coal region, and that at Lodz 120 mi. The system of using coal at the mines to generate current and transmitting by wire is therefore feasible, and considering the inadequate railroad facilities, probably the most desirable. There is opportunity for America to supply these industrial needs, and it is stated that the most welcome plan will be by furnishing the heavy machinery and tools, which cannot at present be built in Poland, and by establishing factories in Poland for the manufacture of lighter machinery and supplies. Poland wants to be economically independent of both Russia and Germany, and will welcome capital and enterprise that will assist her to do so.

There is plenty of engineering talent and skilled labor available in Poland, but money and management are needed to get industry on its feet. One field that offers opportunity is the sugar industry. In 1912 there were 51 factories and refineries, producing 72,646 T. of raw sugar and 54,407 T. of refined valued at $36,000,000. Most of the plants are new, electrically equipped, and the old plants are being remodeled with electric drive and exhaust steam turbines. In the Ukraine there are some 300 old sugar plants that need remodeling to electric drive, and this business would be readily available to firms successfully established in Poland.

These figures give briefly the outlook for power development. To care for handling the financing, plans are now being made for establishing branches of United States banks in Warsaw, Cracow, Lvov, Posen and Lodz, and the Polish National Department has established offices at 32 West 42nd St., New York, in charge of George Fudakowski, formerly with the Westinghouse Co., to give information to manufacturers and exporters in regard to enterprises, loans, credits and material needed.

The Future of the United States Employment Service

EVEN though the failure of Congress to pass the Urgency Deficiency Bill has cut the United States Employment Service down to skeleton form, the national machinery for placing soldiers, sailors and war workers in suitable employment will continue to function and the organization be held together until Congress meets in extra session and provides the funds necessary to carry on the work of finding jobs for the men who have served their country in its hour of need.

The Service, as is generally known, has been cut down 80 per cent, leaving 56 regular officers and about 2000 emergency bureaus for returning soldiers, sailors and war workers. The representatives of the Employment Service in the demobilization camps are retained, and through the co-operation of individuals not connected with the Federal government the Employment Service believes it will be able to keep open many of the offices which it has been announced would be closed, and instead of two offices in New York state alone, there are indications that the number will reach at least twelve.

With the promised co-operation and support of communities and welfare organizations, the work will be continued. Plans already are in operation to arouse and make effective sentiment throughout the country for the continuance of this work, and to assist federal, state, municipal and volunteer agencies to arrange for carrying on employment activities under the general direction of the Federal Employment Service.

John B. Densmore, Director-General of the Employment Service, urges that business, labor, welfare and all other interests in every community in which a Federal Employment office has been abandoned take over the office and its work, in order to help meet the emergency that the country is now facing.

"The work of assisting soldiers, sailors and war workers to suitable employment must be continued at all costs," says the Director-General. "The unemployment area is spreading, and it means industrial insurance to the town or city which takes over an employment office which must necessarily be dropped by the U. S. Employment Service through lack of funds. Aside from sentimental and patriotic considerations, it will be a sound business investment to a community to carry on this necessary work. It is the misery caused by widespread unemployment that breeds social unrest and disturbance and gives the agitator an opening."

In the general cut in the Service it has been found necessary to abolish the Professional and Special Section, as well as the Skilled Labor Section. So far as possible the work of these two important sections will be carried on through the remaining regular offices, and through which high-grade professional and technical men, as well as skilled and common labor, will be supplied. In like manner, men for the farms throughout the United States, for the spring planting, for the summer work and for the harvest will be furnished. Organization by the Council of National Defense of the Emergency Committee of Employment to assist the U. S. Employment Service and enlist community support for the offices of the Service, which must be temporarily abandoned, is expected to be of great aid in meeting the emergency. Also a number of State Legislatures are considering appropriating funds to carry on the U. S. Employment Service organization and work in their states until Congress appropriates the necessary money. Several already have arranged to carry Federal Employment offices over the emergency. In addition to this, large numbers of employes of the Employment Service, deeply interested in the human problem that they have been helping to solve, have volunteered their services for the remainder of the emergency period.

New Design of Double-Packed Stop Cock

SHOWN in the accompanying illustrations are two double-packed stop cocks, one, that pictured in Fig. 1, being for high-pressure service as required on blowoff lines, etc., while the other is designed primarily for general low-pressure work.

The plug, as will be noted, projects through top and bottom glands which not only serve as guides, but as a means of securing the packing at these points, an arrangement which eliminates the necessity of driving the plugs into place to prevent leakage. With the extra depth of packing boxes provided, it is possible to employ two rings of packing, and if desired, the packing may be sprinkled with powdered graphite and cylinder oil, thus making the valve self lubricating.

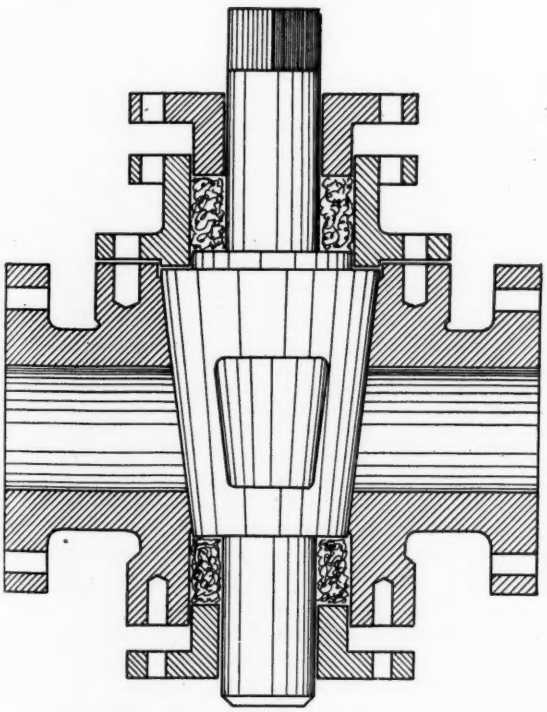


FIG. 1. DOUBLE-PACKED STOP COCK FOR HIGH PRESSURES

Little effort is said to be required to operate these valves, but should the plug turn hard, loosening the nuts of the top gland, and tightening those of the lower one, will insure free action; on the other hand, tightening of the plug is accomplished by taking up on the nuts of the upper gland and letting off on those below. In the care of these valves it is advisable to tighten the top gland to such an extent that the plug is hard to turn, after which the bottom one should be packed in the same manner as the top, the packing being drawn tight enough to release part of the pressure in the plug, after which the cock will be ready for use and will turn smoothly and evenly.

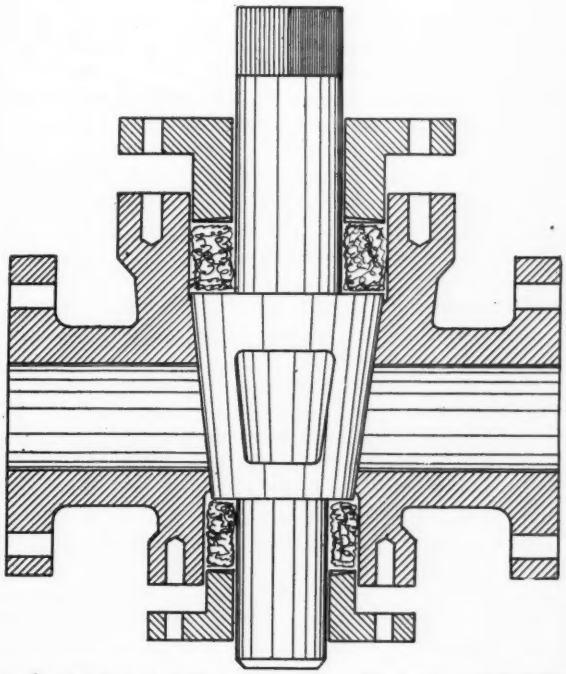


FIG. 2. DOUBLE-PACKED STOP COCK FOR LOW PRESSURES

In addition to their use in steam plants, these valves are said to be particularly applicable for fire hydrants, in petroleum refineries, sugar refineries, acid plants, chemical works, gas works, oil fields and on board sea going vessels.

F. C. HEYLMAN.

Disadvantages of Rapid Combustion

THE STATEMENT is frequently made in print and otherwise that in order to burn coal economically the rate of combustion must be high. In some cases very good results have been attained where the rate was from 15 to 20 lb. of coal per hour per square foot of grate surface, and this I do not dispute, but when it is laid down as a fundamental principle in steam engineering, I object to the idea, because it is not always true. My objection is based on the fact that I have not found it so in practice, and the reports of tests made by other engineers show that in many cases a much lower rate is even more economical.

Some time ago I had charge of a plant where the

normal rate of combustion was 5 lb. of coal per hour per square foot of grate surface, but I could make it 10 at pleasure. The higher rate always took more coal for a given load than the lower.

In another plant where the load was practically constant I laid fire brick on the grates until the effective surface was reduced about 25 per cent, but could not save coal by it.

Tests more recently made, show that while burning 10 lb. per hour, the evaporation was 8.82 lb. of water per pound of coal burned. Under the same conditions, except that the rate was raised to 21.7 lb., the evaporation was 7.77 lb. of water.

Reports of tests made by another engineer show that while burning 8.2 lb. per hour per square foot of grate, the evaporation was 10 lb., and when the rate was raised to 17.8 the evaporation was 9.68 lb. Here the difference in evaporation is small, although the rate was more than doubled, thus showing that it is not always an economical plan. In another plant the rate under certain conditions was 7.5 lb. of coal and the evaporation was 8.91 lb. of water. When this rate was raised to 14.2 lb. of coal the evaporation was 8.87 lb. of water, showing practically the same results. Another test shows that when the rate of coal was 7.3 lb. the evaporation was 10.27 lb., but when the former was raised to 24 the latter was reduced to 9.38.

After considering all of these facts it seems highly inconsistent for certain engineers to repeat the statement that rapid combustion is always more economical than a lower rate.

My boilers are usually operated at about their rated capacity or less, and the brick furnaces have been used for 5 yr. without repairs worth mentioning. During one evaporative test this was exceeded by 60 per cent, with poor results. If operated continuously at that rate the furnaces could not last more than 6 mo., thus increasing the cost of repairs, with no advantage to offset this extra expense.

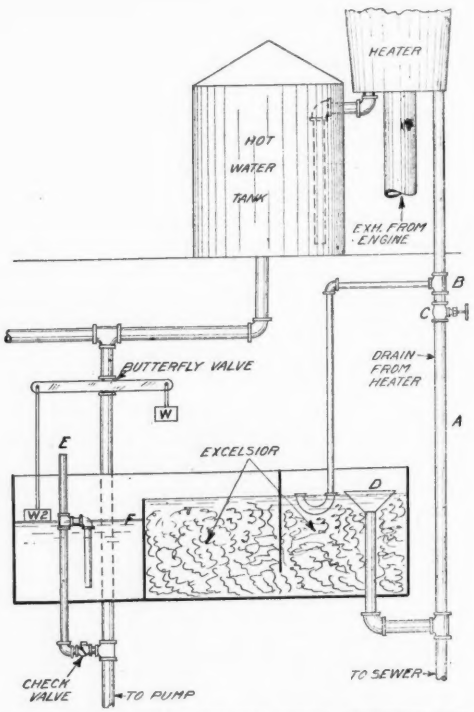
Some reader will probably say that the plant could be run with less boilers, but that would not decrease the initial cost, insurance, etc., because for a few weeks in each year all of them are needed to produce the required steam. W. H. WAKEMAN.

Stopping a Big Waste

UNTIL A few months back, this plant has been wasting 180 gal. of pure soft hot water an hour, because there was no way of taking the oil out of the water. To save coal and avoid other wastes, we figured out a device for taking out the oil and getting the water back into the boiler.

At first the water was going to the sewer through the drain pipe (shown in sketch) at a temperature of 190 to 205 deg. F. By placing a valve and tee in line as shown at B and C, running a line to separator and is carried down through the bed of excelsior in the first cell as indicated by the arrow, and back up through the second cell (also filled with excelsior) over second partition and is brought from the bottom of the third cell up through the pipe as shown and carried to the suction line from tank to pump. When the water in cell 3 raises the weight, W_2, the counterweight W swings down, closing the butterfly valve, thus cutting off the supply from tank until water level in the cell is brought down and the weight W_2 opens the butterfly again, turning on water enough to supply the pump from the tank.

The funnel shown at D is connected to the drain pipe from the heater, extends about ½ in. above water level to prevent the water from running over the sides of the tank, in case the pump is not running fast enough to keep the water out of the way. Also by letting it overflow two or three times each day, it draws the oil



METHOD OF REMOVING OIL FROM CONDENSATE

off the surface and saves changing the excelsior so often. The open ended pipe E admits air in the pipe and prevents the pump from sucking the water below water line as shown at F. JOHN W. FERGUSON.

Using Kerosene in Boilers

ABOUT 8 yr. ago I was employed as helper in a plant equipped with four 250-hp. boilers of the vertical water tube type, an open heater, two boiler feed pumps and an injector on each boiler.

The supply water, taken from a stream back of the plant, was very hard, and, especially after a rain, muddy. It was not long before the boilers began to scale badly, and the engineer who was then in charge was not a believer in boiler compound, although one of the officials of the company insisted on the use of it. Accordingly he sent a barrel to the plant with the request that it be given a trial.

The boiler room being between 10 and 12 ft. below the level of the engine room floor, the engineer proceeded to tap the suction line between the heater and pumps, and ran a ¼-in. pipe to the level of the engine room floor. On this he placed the compound feeder, and after using a small amount, reported the compound as

no good, and had the feeder taken off, but with the ¼-in. pipe left as a vent pipe.

The result was that the mud drums accumulated scale to nearly ¼ in. thickness and began to crack along the front row of tubes on two of the boilers to such an extent that the inspector condemned both of them, and the company, rather than repair them or replace them with new ones, concluded to contract with the central station for power. This resulted in all hunting new jobs except myself and one other, and we were finally held to operate one of the good boilers, which was retained for steam heat, and it was then that my experience with kerosene came in, for I knew that the boiler would be used only a short time, and to avoid having to turbine the tubes and keep down any more scale accumulation, I tried the kerosene. This I did by putting a funnel top on the ¼-in. pipe that formerly held the compound feeder. On the platform around the compound feeder I placed a one-gallon varnish can having an opening in the side close to the bottom and a ¼-in. bib cock inserted.

I then soldered and filled the can with kerosene. The bib cock was opened just enough to allow the oil to feed drop by drop into the funnel, then to the suction line of the pump, through the pump and into the boiler at the rate of about one gallon a day.

After about two weeks I had occasion to repack the plungers of the pump, and was surprised to find that the heavy scale that had formed in the suction line and body of the pump had given way in the form of a soft slush and was cleaning up in fine shape. After about four or six weeks' use, I had occasion to open the boiler, and found the same results on the scale there, only not so marked as in the pump.

I was sorry that my experiment could not carry me over a longer period of time, but it was enough, to my mind, to decide that if I could not use some good method of keeping my boilers free from scale I would use kerosene rather than none at all.

Do not open your boiler when using an open flame, such as a lantern or torch, for there are strong kerosene fumes emitted when first opened, and if an electric light cannot be used, allow it to stand from 2 to 4 hr. before going near with an open flame light. O. E.

Overcoming Bell Troubles

In order to guard a public crossing between parts of a manufacturing plant, a 10-in. vibrating bell was installed in a prominent part. Due to troubles caused by children or rowdies, the bell was incased by wire screen about ⅜-in. mesh, having a wood top and bottom. This worked fine till we had a good sleet and snowstorm; then the hammer would freeze up and the bell would not ring. To overcome this, we simply placed a piece of cheesecloth around the case and the trouble stopped, as the snow and sleet would freeze to the cloth and the bell would ring.

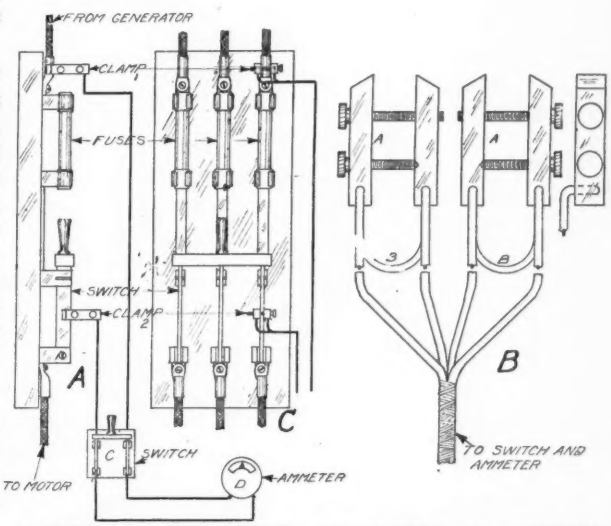
In this plant was installed an automatic call bell system. On being tested out, all bells apparently were all right, as they were ringing in the several departments. Several months later, a material difference of loudness was noticed in different departments. Thinking that this was due to noises in the departments, we paid no more attention to it until one night, when working overtime, we discovered that there really was a difference in tone.

Naturally we first thought that the bell was out of order and we replaced it by another. Still we noted that other bells were ringing just as loud, so we immediately began search for the trouble. As the work was all installed in conduit, it meant quite a search. Beginning at the machine, the junction boxes where taps were made were opened and tested. As is generally the case, the last box showed us the trouble. Here a tap was taken off for two bells in another building. In this the connections were such that at this particular point we had a multiple circuit instead of series. As soon as this was cleared up, our troubles stopped.

Dean B. Cobb.

Inserting Ammeter Without Service Interruption

In the accompanying sketches is shown a scheme which I employ when necessary to take ammeter readings on circuits supplying motors with current, but when it is impossible to interrupt the service in order to insert the instrument.



DETAILS OF CONNECTIONS AND METHOD OF APPLYING AMMETER WITHOUT SERVICE INTERRUPTION

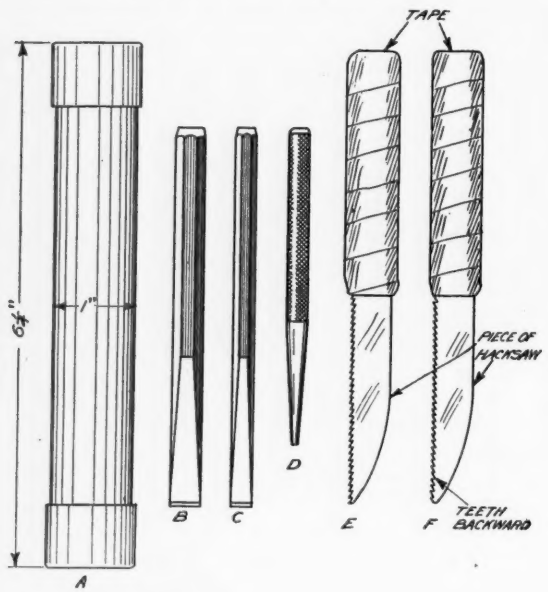
Two pairs of clamps each made up of 2 by ½ by 7-in. pieces of brass well insulated except on the surfaces of contact and provided with 5/16-in. clamping screws 3½ in. long are, as indicated at B, connected to the ammeter. The heads of the clamping screws are made up of knurled hard fiber and the clamp leads, as may be seen, are each interconnected with bridge cables, thus insuring ample conductivity. The two cables from each clamp are twisted together, well taped and connected to a single-throw double-file knife switch, which in turn connects with the ammeter.

In using this arrangement, the clamps are, as at A, so placed as to make good contact at points one on either side of the fuse, preferably one on the switch blade and the other on the lug directly above the fuse. With the ammeter switch in, the fuse may be removed and the instrument will indicate the current flow.

Otto Dorthen.

Useful Vest Pocket Kit

CERTAIN small tools that can be carried in the vest pocket are capable of doing very efficient work, and the advantage is more than apparent when a trip to the tool room or to the shop is rendered unnecessary because something on the spot will do the work. A small cold chisel of good material will often start a small nut or cut off a rivet head that cannot be handled in the regular way. It was necessary to drive a 1½ by ⅜-in. hole in some concrete and the shop had nothing of the right diameter less than 20 in. in length. In this place, on account of pipes and other obstructions, the hammer could not be used on a tool more than 6 in. in length. The vest pocket chisel did the trick in less than 5 min.



A - FIBER FUSE SHELL
B - 3/8" OCT. COLD CHISEL
C - 1/4" OCT. COLD CHISEL
D - TAPER STEEL PUNCH - 1/4" MILLED BODY
E - VEST POCKET HACKSAW
F - TOOL FOR REMOVING CARBON BRUSHES

TOOLS OF VEST POCKET KIT

In another place it was necessary to cut off about ⅜ in. from the end of a ½-in. wrought iron pipe nipple. Regular tools were not at hand, and the small hacksaw shown in the kit made good in a very short time.

In numerous operations where wood screws are used, hard wood is encountered; beams are generally much harder than ceilings, and a small steel punch is almost indispensable.

In putting the end shield on small induction motors a small taper punch is exceedingly useful in lining up the holes. As for the hacksaw with inverted teeth, the writer has found it very useful in withdrawing and loosening up small carbon brushes stuck in the holders, the brushes being of such type that they cannot be withdrawn with the fingers nor seized with pliers. The writer has another similar kit ¾ in. in diameter, 4½ in. over all in length, with both caps removable. It is divided into three compartments. One end compartment contains No. 6 ¾-in. wood screws, the other No. 6 ½-in. wood screws, while the middle compartment contains small screws for lamp sockets, switches, receptacles, etc., which are deposited in the kit every time a screw is picked up or reclaimed from discarded apparatus. When a screw is dropped accidentally and lost it is only necessary to turn to the reserve in the kit, as there are always a dozen different kinds to select from.

The fiber shell in kit No. 2 is bored with a ⅜-in. hole at its middle point and a sleeve of tin slipped over the shell is bored in the same way; by turning the metal sleeve the two holes coincide and the contents of the middle compartment can be dumped out.

T. H. REARDON.

Bench Shear and Emery Sticks

THIS IDEA of a bench shear came to the writer one day when he was making up a lot of electrical connections that required short lengths of wire. The tool is homemade, requiring but a few minutes' time, an old flat 14-in. file and a piece of ¼-in. plate steel. The moving blade is made of the file, the inner side of this being ground smooth. A hole is drifted through for the bolt at A. To do this heat the file red at that point. Drift while hot and grind off the burr when the file is cold. Grind the cutting edge to the regular shear bevel. The rigid blade is made of the ¼-in. plate steel, as shown

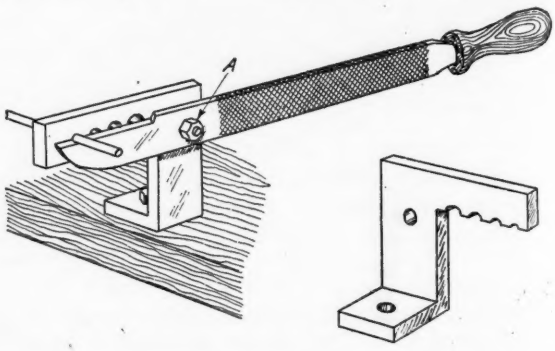


FIG. 1. HANDY HOMEMADE BENCH SHEAR FOR CUTTING WIRE

in detail in the sketch, the different size half holes for wire being filed to suit needs. The bolt that holds the two blades together must be riveted to prevent the nut backing off when working the cutter.

The emery sticks shown in the sketches are easily made from hard wood. Their uses for cleaning and refinishing work seem unlimited. The maintenance man

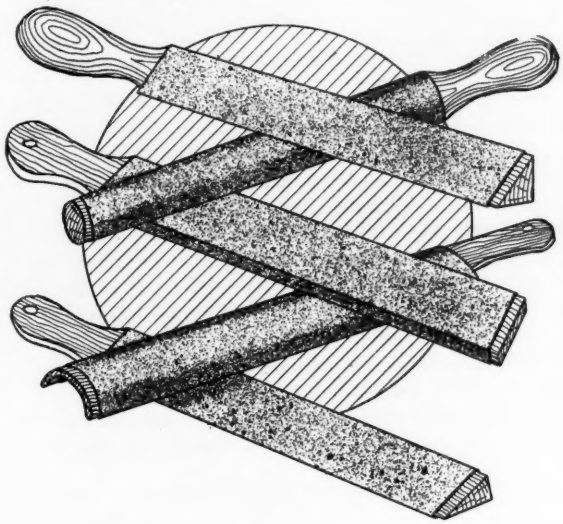
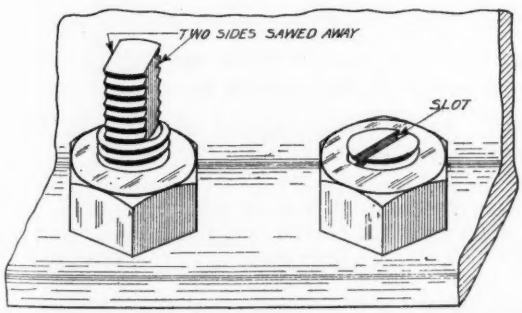


FIG. 2. CONVENIENT FORMS OF EMERY STICKS

who hatched the idea uses them for finish filing and smoothing up work, when refitting bearings, bushings, crosshead guides, etc. The oilers use them for cleaning fillets, sides of nuts, etc. Fish glue and No. 00 emery cloth and the special shaped sticks constitute the material needed. C. H. WILLEY.

Method of Holding Foundation Bolts

ON AN erection job recently, it was found that, due to the carelessness of the concrete workers, the foundation bolts for holding the engines to the foundations could not be pulled up tight because they were not



END OF BOLTS FLATTENED OR SLOTTED TO PERMIT HOLDING WHILE NUT IS BEING TIGHTENED

fastened tight in their sockets and turned around when it was desired to pull up the nuts.

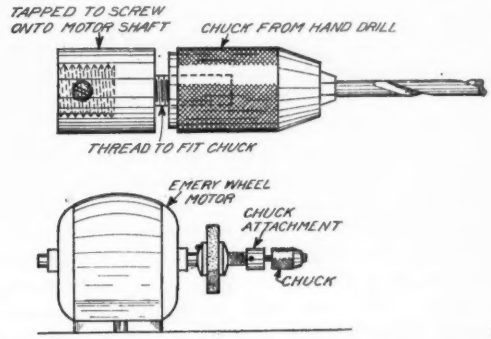
This condition we remedied by hack-sawing off the upper end of the bolt in the manner shown in the sketch, enabling us to grip the bolt and hold it from turning with one wrench, while the nut was being tightened up with the other.

A similar condition often arises in connection with the pulling up of bolts of various kinds where the head cannot be held to prevent turning and this kink of squaring off the top of the bolt so that it can be held from turning should prove of assistance. Where the bolt extends only a few threads beyond the nut, a hack-saw cut through the center to permit the use of a screw driver may sometimes serve the purpose.

M. A. SALLER.

Motor Attachment for Hand Drill Chuck

A HANDY PIECE can easily be machined, or can be had machined cheaply, which will readily make the



THE HAND DRILL CHUCK AND METHOD OF APPLYING TO MOTOR SHAFT

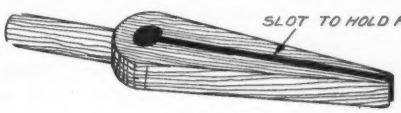
chuck from an ordinary hand drill available for use on a small electric motor.

The accompanying drawing shows the simple piece which will, of course, be made of the correct size and threaded to fit the chuck and motor with which it is to be used. This will be found to take care of any small work which the hand drill was made for, and it also saves much time and labor.

A small vise can be mounted at the end of the motor shaft, and by the use of a worm screw the work can be held and fed to the drill. W. W. PARKER.

Tweezers for the Handling of Fuse Wire

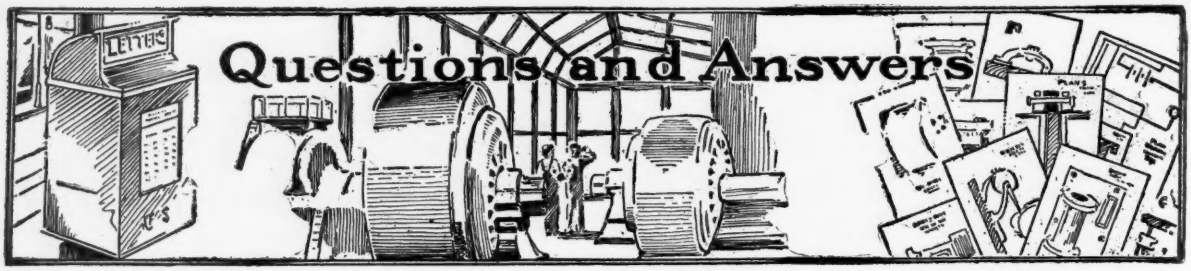
IN THE accompanying sketch is shown a tweezer for the handling of fuse wire. It is made up of ½-in. hard



TWEEZERS FOR THE HANDLING OF FUSE WIRE

wood, works easily and won't break. The slot is but the width of a hacksaw blade. R. G. SUMMERS.

THE PURCHASING POWER of money is very low for the time being. When war matters are fully readjusted, the purchasing power of the dollar will rise. The logical thing to do is this: Invest liberally in the Victory Liberty Loan while money is abnormally cheap. Then you will reap the full benefit of the gradual enhancement in purchasing power. Meantime, the Government pays you good interest.



A Cylinder Lubrication Problem

I HAVE a problem in steam cylinder lubrication which I would like to submit to the readers of Power Plant Engineering.

I have three Fitchburg engines of the piston-valve type, the cylinders of which we have been unable to lubricate properly. We are at the present time injecting the oil into the steam line through an oil nozzle located about 2 ft. above the throttle valve, the oil being delivered from a McCord pump.

The gage pressure at the engines is 140 lb. steam, considered fairly dry. We have no water trouble with cylinders and formerly fed oil into the steam chests immediately over the valves with the same result (dry cylinders). We have used, in the last two months, 12 different kinds of the best oil produced by reputable concerns.

The engines in question are a 1000-hp. cross-compound condensing, a 500-hp. tandem condensing and a 250-hp. simple, the compounds operating with 26½-in. of vacuum.

The boiler feed water is primarily taken from the river and is considered fair boiler water, no trace of acid having been found. The amount of oil used per month we consider as ample, in fact wasted, for a 10-hr. run per day per month using 2 bbl. H. M. S.

Proper Setting of Murray Corliss Engine Valves

IN THE recent makes of Murray Corliss engines, the steam valves cut off before, or just at the end of the wristplate travel, with the governor on the safety stop. In the earlier years of Murray Corliss manufacture, the governor had to rise off the stop before the dashpots got in action; these engines had not the long range cutoff.

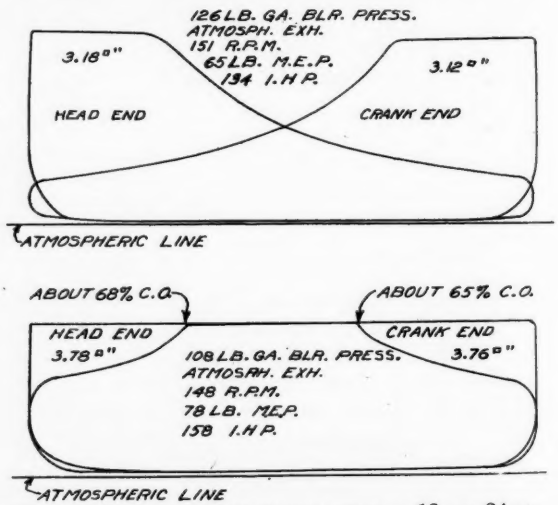
Therefore, judging from T. J. B.'s question, he is dealing with one of the recent engines, which has the long range cutoff.

When erected in the shop the governor is placed on the stop, and the governor, or knockoff cams are fastened to the knockoff levers, in such a position that the valves are tripped just as the wristplate comes to the end of the stroke. Consequently, when starting the engine, the steam valves are always tripped.

The governor setting is not changed afterwards; that is, on a light load the governor rises, and the heavier the load on the engine the lower the governor falls, the regulation of the cutoff being controlled entirely by the governor. In case the load is too great, and the governor falls below the level of the safety stop, the safety cams get into action and stop the engine, by preventing the hooks from hooking up the valves.

For setting the steam valves of a 28 by 48-in. engine, I would say give them 1/16-in. lead, engine dead center. As to the exhaust valves, if the engine is run non-condensing, the exhaust valve can remain open longer than if it is run condensing. In other words, if the engine is changed to condensing from non-condensing, it is necessary to advance the eccentric a little. I usually like more compression on a higher speed than on a lower one. Upon determining at what point in the stroke I wish the exhaust valve to close, I revolve the engine by hand until that point is reached and then set the valve, line to line, to close. Repeat this process on the other end.

I then apply the indicator and note carefully all lines of the diagram and make such changes as may be required. Am enclosing diagrams taken from a Murray engine. These were taken during the test run made after erection, and illustrate the different loads on the engine. The governor setting was not disturbed except that in the diagram of the heavier load the governor was lower down, thus giving a later cutoff. TOM JONES.



REPRODUCTION OF CARDS TAKEN FROM A 12 BY 24-IN. MURRAY CORLISS ENGINE

RELATIVE TO the Corliss valve setting problem of T. J. B., it is my opinion that the governor should be placed in mid position when adjusting the governor reach rods just the same as when adjusting them for ½ cutoff. This will cause the governor to ride in the proper place when the engine is running at the proper speed and cutting off at ¾ stroke.

A cutoff of ¾ stroke under the control of the governor is somewhat late even for a double eccentric engine, for it will give an angular advance of only 45 deg., which

is so small as to give the valves a slow motion in opening, an undesirable feature in any engine.

In general, when setting the valves of the Corliss engine, it is my policy to place the governor in mid position, which is considered to be one-half the distance between the top and bottom collars, and then adjust the governor reach rods to disengage the hooks when the piston has reached the point at which it is desired to have the engine cutoff when carrying normal load.

In considering this problem I am reminded of a question which was asked of me when undergoing an examination for an engineer's license a few years ago, and which may be of interest to some of the readers of Power Plant Engineering.

I was asked at what point the engine which I was operating at the time would cut off under the control of the governor, and I felt fine at being able to tell the inspector that the limit of cutoff under the control of the governor on that particular engine was 0.6 of the stroke; you can well imagine my feelings when he came back with this question: "Assuming that to be the case, how far ahead of the crank is the eccentric?"

I had to admit I could not tell him; however, I was not long in doubt, for I put the question to an engineer friend and he proceeded to tell me how the eccentric position, with relation to the crank, could be found for any engine, provided the limit of cutoff under the control of the governor was known.

It is found as follows: It is evident that the limit of cutoff under control of the governor must occur just as the eccentric reaches its limit of throw, assuming that the eccentric starts from the head end; this point will be reached when the eccentric center has traveled 180 deg. from its starting point. Now assume that the limit of cutoff occurs when the crank has completed ¾ of this stroke from the head end, when the crank has traveled ¾ of 180 deg., or 135 deg.; then, if the eccentric is at 180 deg. and the crank is at 135 deg., the amount that the eccentric leads the crank must be 180 minus 135, or 45 deg.

The incident related happened several years ago, but the explanation which the friend gave was so plain that it remains with me yet. C. B. HUDSON.

Operating Engines Under or Over

I NOTICE the question of D. B. on page 297, March 15 issue of Power Plant Engineering, regarding running an engine under. I have been operating a girder frame Corliss engine rated at 75 hp. for the past 7 yr. running under, and have found no trouble from this source at all. This engine has a load of from 50 to 75 hp. and runs 10 to 24 hr. a day. If D. B. runs his engine under, he will find that the crosshead shoes will require taking up about half as often as when running over. In my case, I have not taken them up for nearly 2 yr. and there is as yet little to take up.

I believe I would much prefer to run the engine under rather than have the pull on the top side of the belt. In fact, judging from past experience, I would not hesitate in running the engine under. ROYCE MOSER.

BUY THE Victory Liberty Loan, of course. But buy it out of what you have saved since the Fourth Loan and keep on paying installments out of your current economies.

Examination Questions for a Massachusetts First-Class Engineer's License

KINDLY PUBLISH with answers the following questions recently asked an applicant for a Massachusetts first-class engineer's license. A. M. D.

1. What are the principal advantages of compound engines?

A. The advantages gained with a compound engine over a simple engine are: The cylinder condensation is reduced on account of the reduction in the temperature range, and the ratio of expansion per cylinder; the reduced leakage loss on account of a reduction in the pressure difference which causes leakage; third, higher mechanical efficiencies, since the ratio of the maximum to the mean effective pressures in each cylinder is greatly reduced; fourth, the principal parts of the engine are less heavy and costly, since the maximum total steam pressure on each of the pistons is only from 20 to 30 per cent of what it would be for a single-cylinder engine employed, having the same total ratio of expansion; the fifth advantage is that by causing two or more cylinders to operate on separate cranks on the same shaft, as is done in a cross-compound engine, a more even turning moment may be secured, which is a matter of great importance in the case of engines operating alternating current generators in parallel.

2. How would you determine the proper receiver pressure to carry on a compound engine?

A. See answer below.

3. How would you tell what receiver pressure to carry on a new compound engine before starting up?

A. Receiver pressure is determined by the point chosen for cutoff in the low pressure cylinder; with an earlier cutoff, the receiver pressure rises correspondingly. The low pressure cutoff should be such that indicator cards from the two cylinders show the work done in the two cylinders to be equal.

An approximate method of calculating receiver pressure is to assume that each cylinder is built to carry a pressure which would allow equalizing the load between the two cylinders. We can then figure equal expansion in each cylinder in the following way: We will assume that the initial gage pressure is 120 lb., and that a vacuum of 25 in. is being maintained. The absolute initial pressure is then equal to 120 plus 15, or 135 lb. A 25-in. vacuum is practically equal to 25 divided by 2, or 12.5. Fifteen minus 12.5 is equal to 2.5 lb. as the absolute back pressure in the low-pressure cylinder.

The total number of expansions is equal to 135 divided by 2.5, or 54, or in each cylinder is equal to the square root of 54, or about 7. Now the high-pressure terminal and receiver pressures are the same, so that 135 divided by 7, or 19 lb. is the allowable pressure.

4. Why not raise the receiver pressure and place more load on the low-pressure side?

A. For smooth operation, it is desired to distribute the load evenly between the two cylinders. Should the low-pressure cylinder prove indolent, the low-pressure cutoff should occur earlier until the indicator cards show the work of the two cylinders to be equal.

5. Would there be any harm in running the receiver pressure below atmosphere?

A. It will depend upon operating conditions. Partial vacuum in the receiver will render a pressure steam

trap worthless, the water passing from receiver to cylinder with damaging results.

6. What kind of a trap would you use on a receiver?

A. If conditions warrant the use of the condensate for feed water a return trap should be employed, otherwise use an ordinary trap and throw water to heater.

7. If you had a solid end connecting rod with piston rod screwed into crosshead, how would you equalize the clearance?

A. If the piston rod is screwed into the crosshead, and secured by jam or lock nuts, the rod may be turned around a sufficient number of times, either forward or back, to bring the piston to a position that will equalize the clearances; it must be understood, of course, that there is a limit to the number of turns a rod should be moved in either direction. In turning the rod around care should be taken to see that he piston does not have to assume a new position in relation to its wearing places in the cylinder; in other words, the rod should be turned fully one complete turn and not a fractional part.

8. In an old engine, would there be any objection to changing the piston rod?

A. No.

9. How would you equalize the clearance without changing the rod?

A. If the piston rod is attached to the crosshead by means of a fixed key or wedge, clearances may be equalized by using shims at the stub end of the connecting rod.

10. At which end does the clearance increase by taking up a solid end rod?

A. If it is taken up between crosshead pin and crank pin, thus lengthening the rod, head end clearance will be reduced and crank end clearance increased. If taken up at outside the pins thus shortening the rod, the opposite is true.

11. What causes an engine to pound when shutting off the steam?

A. Without a knowledge of the particular conditions, an answer is largely a guess. Play in the piston or rod might be responsible.

12. What causes an engine to pound under overload?

A. Most pounds are caused by lost motion of some reciprocating part or loose bearings. In this instance the defect may be so slight as to be noticeable only at heavy load.

12a. What causes an engine to pound at one end?

A. Probably incorrect clearance at that end, faulty bearings or a loose piston.

13. What are the causes of the exhaust valve pounding the bonnet at the end of the stroke?

A. Possibly due to the exhaust opening being too early or too late, the exhaust passage outside of the cylinder being contracted, or end play of the valve.

14. How would you test a surface condenser for leaks?

A. About as good a way to tell whether a surface condenser is leaking or not is to exhaust the steam to atmosphere for a while with the condensing water still running into the condenser. If water collects in the steam space of the condenser it is proof that leaks are present.

15. How would you test each tube for leaks?

A. To determine what tubes are leaking, a simple method is to take off the heads of the condenser and fill the steam space of the condenser with water under pressure. Then by watching the tube sheets, any leaks around the tubes or through holes in the tubes can readily be seen.

16. On which side of the tubes of a surface condenser is the circulating water?

A. The water travels through the inside of the tubes.

17. What is the function of a dry vacuum pump?

A. To remove gases, chiefly air, from the condenser head of a barometric or jet condenser or from the upper part of a surface condenser and thus increase its operating efficiency.

18. What is the difference between the suction valves and the discharge valves in such a pump?

A. To control suction, a positively driven Corliss or slide valve is frequently employed, poppet valves being used on the discharge side.

19. Why are suction valves mechanically operated?

A. Mechanical operation of the suction valves permits a relatively high rate of speed, ensures the opening of the valve at the proper time, and uncovers a port entirely free from obstructions (such as valve guards, disks and springs).

20. If the connecting arm on an inertia governor should break, how would it affect the speed of the engine?

A. The heavy end of the bar of a Rites inertia governor tends to lag behind and the restraining action of the spring balances this tendency. If the bar were to break above the spring connection no counter pull could be exerted on the spring and it would draw the eccentric into full throw position, permitting the engine to speed up.

21. How would you set the valves on a 30 by 60-in. engine without any counterweight on the crank?

A. Without counterweight, the head end valves of an engine running over might have a slightly greater lead and a little earlier cutoff than the crank end valves. This will compensate for the slight additional work required to lift the crank and connection rod. This provision is of more importance in a vertical engine.

22. How would you run a compound engine if you were having trouble from running with receiver pressure below atmosphere?

A. If the trouble consists of portions of water from the receiver entering the low-pressure cylinder, measures should be taken to have the receiver drained with a positive acting trap. Also shorten low-pressure cutoff.

23. How would you run a compound engine if the high-pressure cylinder should give out?

A. The boiler pressure should be reduced; an explanatory method for determining the new pressure is as follows:

We assume that your cylinder ratio is the ratio of volume 4 to 1, 110-lb. pressure, 28-in. vacuum, and we will assume, also, that the cutoff is at ¼ stroke in the high-pressure cylinder, and that the total ratio of expansion is 16.

To find the mean effective pressure in the high-pressure cylinder, we divide the initial pressure absolute,

which is 110 plus 15, or 125 lb., by the ratio of expansion 4, and multiply this by 1 plus the hyperbolic logarithm of the ratio of expansion. For the ratio 4, this logarithm is 1.39. We then have, 125 divided by 4 multiplied by 2.39 equals 74.7 lb., the mean forward pressure. From this we subtract the receiver pressure, which is 125 divided by 4 or 31.2 lb. absolute, leaving as the mean effective pressure in the high-pressure cylinder, 43.5 lb.

In like manner the mean effective pressure in the low pressure cylinder is 31.2 divided by 4 multiplied by 2.39, which equals 18.65 lb., and from this we subtract the back pressure, which is your vacuum pressure, 0.98 lb., leaving a mean effective pressure of 17.67.

Now, to get the same effect in horsepower, we shall have to have a mean effective pressure on the low-pressure cylinder equal to that when the engine is running compound, plus ¼ that on the high-pressure cylinder. Dividing 43.5 by 4, we get 10.9, which added to 17.67 gives us 28.57 as the mean effective pressure when using the low pressure alone. The mean forward pressure will be this amount plus 0.98, the back pressure, or 29.55 lb.

From our equation above, assuming cutoff still remains at ¼ stroke, in the low-pressure cylinder, we should have this mean effective pressure 29.55 plus 2.39 multiplied by 4, which gives us 49.5 lb. as the initial pressure absolute, and from this we subtract 15, giving us 34.5 lb. as the gage pressure at which the engine should be run.

24. What kind of oil would you use in the high and low-pressure cylinders?

A. Ordinarily the same oil is employed for lubricating both cylinders. In special instances when excessive condensation is present in the low-pressure cylinder, an oil containing a trifle more tallow or lard oil is employed to resist the abnormal washing effect of the water.

25. How would you connect a B. & W. boiler with superheater to obtain saturated steam for pumps?

A. A flange connection to the rear top of the boiler would be required. If a considerable amount of saturated steam is to be taken off for large pumps or an engine, there is a possibility of overheating of the superheater due to insufficient heat conduction. This point deserves consideration.

26. What is the cause of and how would you stop the side slam on an eccentric strap.

A. This side movement is either due to improper alinement of the eccentric rod, or uneven wear on the eccentric strap. Test up alinement, and if uneven wear is found, rebabbit the strap.

27. Why does not the strap wear round and in taking it up where would it bind if it was worn?

A. The strap tends to wear oval, with its horizontal diameter greater than the vertical because pressure in a horizontal direction is exerted upon the strap each revolution by the transfer of motion from the eccentric to the eccentric rod.

28. Explain what you would do if the exhaust valve stem in an engine you were running broke off.

A. To keep the engine in operation the valve should remain open by disconnecting the link. The corresponding admission valve should be closed by disconnecting the link. The engine would then operate single acting on one end. It would make no difference which end was broken.

29. How is the B. & W. superheater attached to a boiler?

A. The superheater of a B. & W. boiler is suspended at the front and rear by rods attached to bars extending across the top of the drums. The saturated steam travels through a dry pipe with open end toward the rear of the boiler, extending through a flanged opening in the bottom of the drum about ⅓ of way from the rear. The superheater delivery pipe extends from the outside end of the bottom leg of the superheater around the outside and to the top of the drum.

30. If you were operating a cross compound engine and the low-pressure side steam valve broke off at the stem, what would you do to keep the engine running?

A. See (28) but lengthen cutoff on low pressure to prevent excessive receiver pressure.

31. What causes the nipples to leak in a B. & W. boiler?

A. It is presumed that you refer to the nipples in the mud drum. Usually where there is much leakage of the nipples in the mud drum of a B. & W. boiler, it is due to the fact that they are not properly rolled in. They should be expanded into the mud drum, but not beaded over.

It may be that the mud drum is resting on the brickwork, so that, as the boiler heats up, there is no chance for the nipples to expand. In this case, there will be a tendency for them to work back and forth in the mud drum, and this will cause leakage.

32. How would you test a closed heater for leaks?

A. If a closed heater leaks, the excess water present in the exhaust steam will indicate the faulty operation. If there are drains in the exhaust line the water will escape.

33. What is the proper position for crank in keying crankpin? For wristpin and crosshead?

A. To key the crankpin or wristpin, place the crank at about 135 deg. post or 45 deg. ahead of dead center. Crosshead will be at about mid travel.

Correction Note

On page 297 of the March 15 issue is given an answer to a power transmission problem in which there are presented a number of formulas for the calculation of shaft diameters. These as published are incorrect, due to the fact that in each case a plus instead of a division sign is employed. Correctly stated, these formulas are:

$d = \sqrt[3]{90 \text{ hp.} \div N}$ for turned shafts;

$d = \sqrt[3]{70 \text{ hp.} \div N}$ for cold rolled shafts;

d is the diameter of the shaft in inches, hp. is the number of horsepower to be transmitted, and N is the number of revolutions per minute at which the shaft is to turn.

When the shaft is a head shaft carrying the main driving pulley and distributing power to receiving or line shafts, and is well supported by bearings, these formulas will be employed:

$d = \sqrt[3]{125 \text{ hp.} \div N}$ for turned shafts;

$d = \sqrt[3]{100 \text{ hp.} \div N}$ for cold rolled shafts;

$d = \sqrt[3]{90 \text{ hp.} \div N}$ for all general work.

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Better Lubrication

Improvements usually come fast in new industries, but as the methods and means develop towards the 100 per cent efficiency mark the progress is like the geometrical progression of a fraction; it comes practically to a standstill. The power plant is no exception to this rule and we are now getting to the point where improvements in principal machinery and methods employed in our most modern plants are coming very slowly.

More and more is the industry being split up into departments or specialties, so much so that you find but few all around power plant specialists. Like physicians, engineers who wish to make a name for themselves are specializing in one or two branches of the industry after they have gained sufficient general knowledge and experience to make a success as a specialist. Boilers, economizers, fuels, furnaces, feed water, engines, turbines, lubrication, each and every one of them is of sufficient importance and presents problems of sufficient difficulty to tax the mental capacity of our best engineers before any marked improvements can be made and our only hope for general progress is through combined efforts of those who give an unusual amount of time and study, taken up in practical experience and experimentation, to these and other phases of power plant work.

Take, for example, the question of lubrication. It has been but a comparatively short time since this has been in the special class, yet in that time and due to the knowledge of lubricants, high temperature steam for reciprocating engines has been made practicable; gas and gasoline engines, air and ammonia compressors have had their special lubrication problems solved, which, for a time, retarded their development; bearings of all kinds have increased in efficiency; reclamation of oil has reduced expense of lubrication; removal of oil from exhaust steam has lowered feed water costs. Wherever two surfaces work against each other, a lubrication problem is met and upon its proper solution depends the success of the apparatus. Can anybody say it is too narrow a subject to engage the entire thought of a number of men of exceptional ability?

On other pages of this issue, Mr. Trautschold gives considerable data on lubricating oils which brings to readers the latest developments in the use of oils as well as methods of testing and selecting. Careful use of this information will, we believe, bring power plants a step closer to that ideal 100 per cent.

Training for Executives

In 1906 we learned of a scheme for developing superintendents and managers of central stations. It looked good on paper; there was even a guarantee attached to the contract proposed, but the training had to be taken away out in Denver where a great many wild-cat schemes, particularly in mining, had been hatched and used to fleece people out of their money, so why not a young man out of the benefits of his labors?

That was thirteen years ago. Today we find the Henry L. Doherty interests among the leaders in the central station field. We also find that those young college graduates who entered the Doherty Training Schools in those early years of the development are just

what it was promised they should be—superintendents and managers.

The story of how these executives can be developed as told elsewhere in this issue is indeed interesting and points clearly to the fact that men in business can depend as definitely upon men selected upon character and training to carry out general policies and meet emergency conditions satisfactorily as can the engineer upon the results to expect from selected coal.

To the young man expecting to make the power plant business his life's profession, we would suggest that he make a careful consideration of the Doherty Training Schools as one of the steps in his preparation.

The German Code

NOW THAT the war is over and we are joying in the return of our boys, there is danger that we forget the grim reason why they went. We have not at hand, as have the French, the evidences of a diabolical spirit of destruction and carefully planned devastation to keep us resolute that those who wrought the misery and distress shall be made to realize the fiendishness of their deeds.

So it is well that we read frequently of what those who have visited the ruined regions find there, shall hear from our returning soldiers the stories of merciless cruelty, and shall see often the pictures of the one-time busy and happy towns reduced to shapeless ruins.

Damage is inevitable in a region where war is waged. An enemy in an occupied territory may be justified in appropriating material to meet its needs. But wanton destruction of property which cannot be used, and the murder and torture of unresisting civilians is barbarism that has no excuse.

Speaking of his trip through devastated France, with the party of business paper editors who went as guests of the British government, Henry G. Lord tells of conditions as he saw them a few days after the signing of the armistice.

"The impression of that first day at the front can never be forgotten nor can one adequately describe the scene. Pictures, of course, give a good idea, but there is something about the reality that neither written words nor camera can convey. It is the difference between reading the account of a play and seeing it acted. I had heard others express this thought, and could not understand its full significance until I had seen for myself."

Hundreds of manufacturing villages were utterly wiped out, and are marked only by a signboard, "Here was Souchez" or whatever may have been the name. In some cities like Lille the external damage to buildings did not seem great, but all electrical machinery was systematically listed and carried away, linen and flax machinery was destroyed and the brass parts of cotton machinery removed and carried off, no care being taken to avoid injuring the remaining parts.

Three hundred thousand cotton spindles, 15,000 looms, 1,000,000 wool and worsted spindles and 30,000 looms were destroyed for no reason except to ruin French industries. Destruction of orchards and forests has been repeatedly told in the newspapers. Dwellings, even in towns not subject to bombardment, were systematically ruined by the retreating boche. In Douai there was no damage of consequence from shell fire. A few days before the Germans left the population was sent away, and every house was gutted, furniture smashed, carpets ripped up and torn, pictures cut, beds ripped open, books slashed, family photographs torn to bits.

Not in a few houses, but in every house throughout the city was this done. It could serve no possible military purpose and was too thorough to be other than wholesale destruction, carefully planned and systematically carried out.

"We found in one of the fine houses of the city, its owner, a doctor, who had remained during the German occupation. He represented the International Red Cross, and his house was occupied by German Red Cross officers whom he entertained to the best of his ability. They enjoyed his wines, admired his pictures and treated him as a friendly and respected host. A week before the evacuation he was sent away, and on his return found his home the most hopeless wreck imaginable, all carefully carried out under the supervision of his Red Cross friends!"

Shall such actions be forgotten? Are we to grant that the people of a nation responsible for such outrages shall be treated as civilized and received among those whom it has outraged? No precept of humanity or Christianity entitles the Germans who have done such things to any consideration until they have repented and paid for their evil deeds. It will be a poor gratitude to our soldiers who have suffered and bled that such an enemy might be beaten if we weaken in our task of teaching the boche that his code has no place in modern civilization. It may, probably will, be years before he learns the lesson, but learn it he must, or Europe will never be free from the menace of his onslaught and the war will have been won in vain.

Belt Hints

IF you want a belt to last, don't try to buy the lowest grade that will do the work at the cheaper price. Take the belt salesman into your confidence. Tell him what the belt is expected to do and get his advice.

Don't run a belt so slack that it will slip. The heat from the friction will burn the leather. Also somebody is likely to use resin to stop the slipping, and resin, used persistently, will ruin a belt.

Running a belt too tight is as bad, for it will injure both belting and shafting. With a good dressing to keep it flexible, a belt will pull all the load it should carry without stretching it to drumhead tightness.

When a belt runs suddenly to one side, after being apparently all right, it may be laid to a sudden load, dry bearings, or belt too loose. Evidently it will be necessary to reduce the load, oil the bearings or take up the belt, and perhaps all three.

Continuous running to one side is due to the shafts not being parallel. The belt will run to the low side, and the driven shaft must be lined up.

Poor lacing will cause a belt to run irregularly, even with pulleys and shafting in line. The lacings should be even, uniformly distributed across the belt and should hold the squared ends of the belt parallel.

Best speed for a belt is found by experience to be 4000 ft. a min. To get the belt speed, multiply the pulley diameter in inches by the revolutions per minute and by 0.2618.

Turbine Reduction Gears

IN the design of the reduction gears illustrated herewith there are a number of features which are particularly interesting making them simple, reliable and interchangeable.

The gears and pinion are of the stub-tooth, double helical type, generated to true form on a gear shaper. The accuracy of this method of tooth generation is such that no grinding or scraping process is necessary to insure perfect contact of tooth surfaces. The gears and pinions are interchangeable, an advantage not often found where the final finish of the teeth is by grinding or scraping.

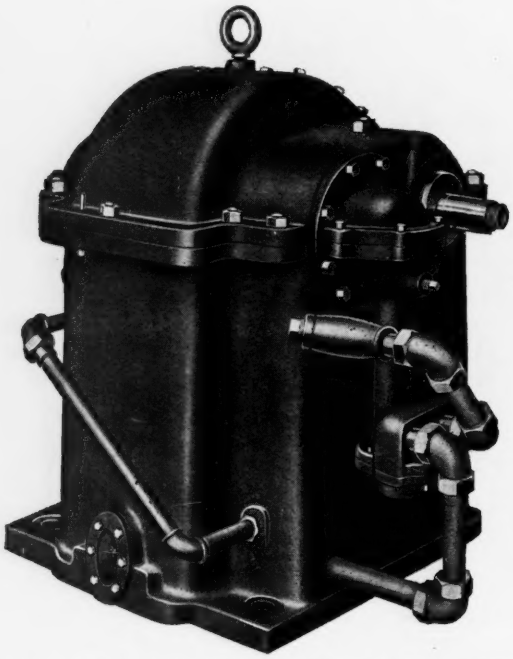


FIG. 1. REDUCTION GEAR SHOWING OIL PUMP AND OIL PIPING

A well-ribbed, double-walled, box-like structure, extending the full depth of the case, forms a rigid support for each pair of bearings. The space between the walls acts as a water jacket for cooling the oil. The ribs between the walls act both as stiffening members and water baffles. The central part of the case, directly under the gears, forms an oil reservoir which contains sufficient oil to supply not only the gears, but also the turbine.

The case being of the double walled, rigid, box-like structure, accurately maintained alinement of the gears is insured. The casing is bored with the aid of fixtures, the dimensions and alinement of the boring being checked by accurate gages. This results in a tight and rigid fit of the bearings which are of ample size, insuring safe pressures and rubbing speeds. They are split horizontally to permit their replacement without removing the couplings. The bearing shell is of cast iron and, as can be seen by the accompanying cut, is unusually heavy. This is to prevent warping or "pinching-in" from heating, which so often occurs in thinner shells of bronze or similar metal. The lining used is of highest grade tin base babbit on both gear and pinion. The bearings are accurately machined to close limits and require very little scraping. Their interchangeability

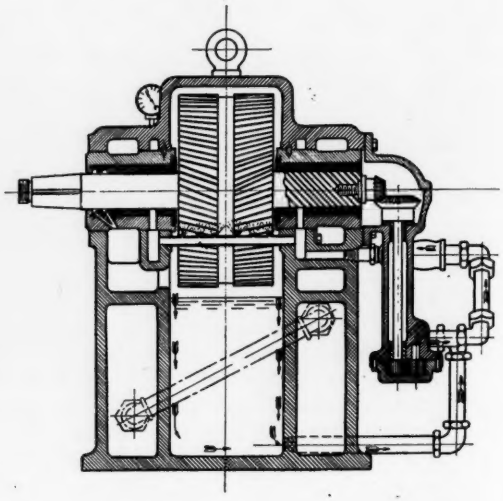


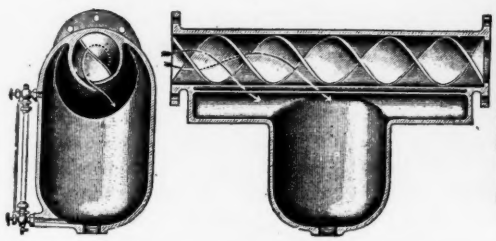
FIG. 2. SECTIONAL VIEW OF TURBINE GEAR

makes it possible in case of excessive wear, easily and quickly to replace them and restore the original alinement.

The oiling system employed is particularly interesting. It is a forced feed system, with the oil pump located well below the oil level in the reservoir, to avoid suction lift, thereby preventing ruin of the gears, due to possible failure of the pump to function. The oil is pumped from the reservoir through short, direct, brass piping to a self-cleaning strainer, thence through distributing passages to large, annular oil pockets around each bearing shell, and through the spray pipe from which the oil is sprayed, for lubrication of the gear teeth. The oil pressure gage is located in one of the above-mentioned annular oil pockets at the most distant point from the oil pump.

The pump and its bevel gear drive make a complete unit without stuffing boxes, or exposed running parts. The unit is so constructed as to be easily accessible. The pump gears may be removed for inspection without disturbing the driving mechanism or oil piping. The bevel gears may also be inspected by removing a small cover. The effectiveness of this lubricating system has been proved by test for, without any water cooling, the temperature of the oil after long runs is less than that found in most gears when running with water cooling.

In spite of the cool operation of the gears, a water cooling system forms part of the standard equipment. This system is of particular interest, being in contrast to the usual method of water cooling coils. The water cooling jacket is hydraulically tested and when it is once found to be water tight it is certain that it will always remain so. Because the cooling jackets are in the bearing ends of the case, heated oil draining from the bearings and gears comes immediately into contact with the cooling surfaces before it has the opportunity to heat the oil in the reservoir.



STEAM SEPARATOR WHICH EMPLOYS CENTRIFUGAL FORCE PRINCIPLE

The gears may be furnished for either direction of rotation, the only change being location of the oil spray piping above or below the contact point.

Drying Steam

CENTRIFUGAL force is one of the most effective agents for removing moisture from steam, and is the principle employed in the Mosher separator. In passing through, the current of steam is caused to revolve by a spiral, so that water, oil and other foreign matter are thrown outward, and are "shaved off" by overlapping slotted openings, isolated from the steam current and conducted to the drain.

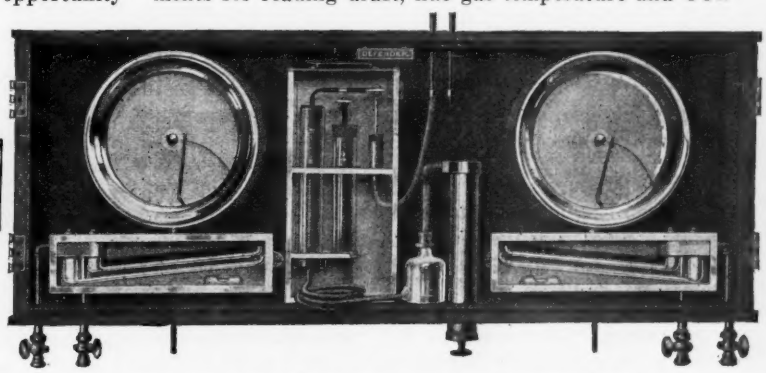
To remove back pressure, the spiral is designed with long tangential surfaces, and no obstruction is placed in the steam passage. By the scrubbing action of the steam the surfaces are kept clean, and the "shaving" action of the slots gives positive separation and removal of the moisture at several successive points.

Advantages of securing dry steam are well known, particularly where small steam space in the boiler or forcing results in entrainment of a considerable amount of moisture. Also the removal of oil from exhaust steam is important when the exhaust is to be used for heating or industrial purposes; and in refrigerating plants extraction of the oil from the ammonia gas is essential to efficient operation of the cooling coils.

Mosher separators are designed especially for such work. They are made for pipe lines from 1 in. to 48 in. diameter, one type being made for installation inside the boiler, so that moisture will be thrown back directly to the water space, thus preventing wet steam from entering the piping system. Cast iron is used for pressures up to 200 lb. and cast steel or steel plate for higher pressures.

Instrument Case for Two Boilers

ARRANGING boilers in batteries of two is quite common practice in modern power plants; the convenience therefore of having the instruments serving the two boilers of the battery mounted on the same board, pedestal or, better still, within the same case is apparent to all who have the operation of boilers under their care. In the illustration is shown this new arrangement where the double case contains instruments for reading draft, flue gas temperature and CO_2.



NEW DOUBLE INSTRUMENT CASE FOR DETERMINING CONDITIONS IN TWO BOILERS

Two recording flue gas thermometers are provided; one for each boiler, also two duplex draft gages for indicating the draft through fuel bed and gas passages separately. A single-chamber Orsat, however, serves both boilers for determining the percentage of CO_2 in the gases. This is provided with a gas suction pump which enables a rapid determination of CO_2. The case is furnished with a double set of doors with two glass fronts to allow the operator to see the draft gages and flue gas temperature instruments, the center of the case, however, containing the Orsat is not visible when the doors are closed.

THE AMERICAN Manufacturers' Export Association has been informed of the appointment of George P. Toby, long connected with banking and industrial corporations in this country, as Executive Secretary of the American Chamber of Commerce in London. Mr. Toby will sail for his new post about May 12. In the meantime, he will attend the coming meetings of the National Foreign Trade Council and the U. S. Chamber of Commerce, for the purpose of conferring with American merchants as to the service which the American Chamber in London can render them. Mr. Toby has long been known as an investment banker, and in this capacity has made a careful study of the operation of American industrial and public utility corporations.

News Notes

OHIO ELECTRIC LIGHT ASSOCIATION will meet at Cedar Point, O., July 15-18, at the Breakers Hotel.

NATIONAL ELECTRIC LIGHT ASSOCIATION will hold its annual convention at Atlantic City May 19-23.

MAY 12-14, the Southwestern Electrical and Gas Association will meet at Hotel Galvez, Galveston, Texas.

SPRING MEETING of the American Society of Mechanical Engineers will be held in Detroit at Hotel Statler June 17-20.

ANNUAL CONVENTION of the American Institute of Electrical Engineers will be at Lake Placid Club, Adirondacks, N. Y., the week of June 23.

RUDOLPH E. LEE, A. I. A., of Clemson College, S. C.; T. A. MacEwan, of Pittsburgh, Pa., and A. R. Turnbull, of Charlotte, N. C., have opened offices at 1214 Realty Building, Charlotte, N. C., for the practice of architecture and engineering under the firm name of Lee, MacEwan & Turnbull. A. R. Turnbull is the business manager of the firm, and they will be glad to receive manufacturers' samples and catalogs.

C. E. HAGUE, formerly Production Engineer of the Mid-West Engine Co., Indianapolis, Ind., has been appointed Sales Manager of the American Steam Conveyor Corporation, Chicago. Mr. Hague assumed his duties March 17.

MAJOR CARLISLE MASON, returning from France, and having resigned his commission in the United States Army, will resume the practice of general engineering in a consulting capacity, assisted by a staff of experts in the specialized branches, with offices at 207 Broadway, New York.

FRED H. WALDRON, formerly Minneapolis representative of the Chicago Pneumatic Tool Co., has been appointed manager Pneumatic Tool sales division, with headquarters in the Fisher Building, Chicago.

PLANS ARE NOW in the making to carry on a most intensified national campaign in behalf of War Savings immediately after the Victory Liberty Loan campaign, especially among the foreign language speaking people of our country. It is intended to use as a working basis the foreign language divisions which have been organized in the various Federal Reserve districts in behalf of Liberty Loans.

Book Reviews

STEAM ENGINE TROUBLES, by H. Hawkens; 284 pages, 276 illustrations; first edition, 1919; New York. Price, $2.50.

Spite of the high degree of perfection reached by the modern steam engine, more or less trouble is encountered in daily operation and though an engineer may have had many years of experience these troubles, their causes and remedies form a large and not unimportant part of his professional life, especially so if he is in charge of a plant containing a large amount of equipment with its numerous and differently arranged parts.

It evidently has been the desire of the author of this book to assist not only the beginner, but also the experienced man, whose time is limited and who has not had the opportunity to come into personal contact with the new features which have been introduced, to become familiar with the possible troubles to be encountered in the operation of the steam engine and the best means to employ for overcoming them. The troubles to which the principal parts of an engine are subject are described, good design is contrasted with bad, and the most suitable material and the most approved form of construction for the various parts are pointed out. The directions given for correcting existing evils are easily understood and by following them, breakdowns and costly accidents may be eliminated. Building of foundations, setting of templets, erection and lining up are given consideration.

There are directions for lubrication, valve setting and testing, means by which to locate trouble with an indicator and adjustments necessary on both new and old engines.

Simple rules for calculating safe pressures for main bearings, stresses in flywheels, strength of cylinder walls are also given, thus enabling the engineer to determine whether the engine he runs is constructed on sound principles or not.

TECHNICAL PAPER 207, just issued by the Bureau of Mines, Department of the Interior, details combustion experiments with North Dakota lignite and develops the requirements which must be met by the furnace for burning lignite or its carbonized residue. The publication also gives the results of experiments with a furnace especially designed to meet the fundamental requirements as disclosed by the study of combustion.

Lignite is difficult of ignition, disintegrates in the fire, presents a high resistance to the flow of air through the fuel bed, loss of fuel through the gas is excessive, and there is frequently difficulty from clinkering. A great deal of experimenting has been done with specific devices for more efficiently utilizing this fuel, but a study of the fundamental principles in the combustion of the fuel has been greatly needed. These principles are found in this technical paper.

Copies of this publication may be obtained free of charge by addressing the Director of the Bureau of Mines, Washington, D. C.

Trade Notes

BERNITZ FURNACE APPLIANCE CO., of Boston, Mass., has purchased all United States rights to the Bernitz invention (patent allowed), in furnace wall construction for the prevention of clinkers.

THE HYDRO-ELECTRIC POWER COMMISSION of Ontario has placed an order with the Westinghouse Co. for two 45,000-kv.a. vertical water-wheel generators of 12,000 v., 3 phase, 25 cycles, for its Queenstown Development. These will be the largest water-wheel generators ever constructed and indicate that the Hydro Commission Development think there is no time like the present for construction work.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

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POWER PLANT ENGINEERING

Heat of Combustion

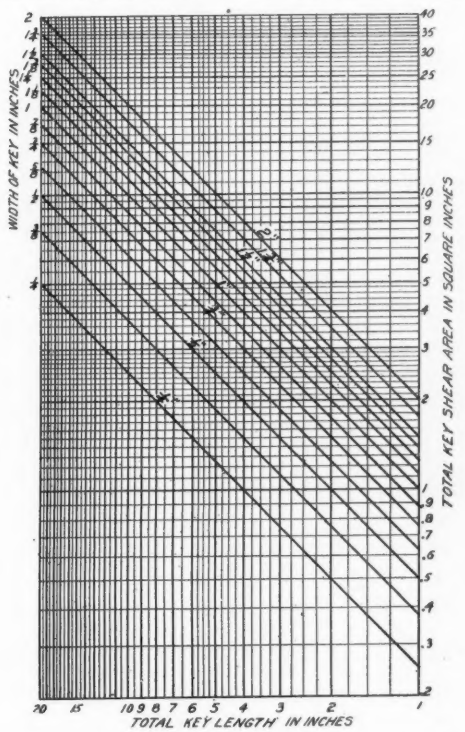
	Calories per Gram	B. T. U. per Pound
Alcohol, Ethyl	7184	12931
Benzol, Liquid	10030	18054
Carbon, Crystallized	7859	14146
Cellulose	4208	7574
Charcoal	8080	14544
Coal, Anthracite	7800–8400	14000–15200
Bituminous	7800–8750	14000–15750
Coke	7900–8040	14200–14500
Gas, Acetylene	11927	21469
Coal	4400–7370	7990–12266
Oil or Petroleum	10800	19440
Producer	773–1370	1391–2466
Water	2000–3000	4200–5400
Gasoline	11733	21120
Glycerine	4316	7769
Graphite	7901	14222
Hydrogen	34462	62032
Kerosene	11186	20135
Lignite	6000–7000	10800–12600
Magnesium	6077	10939
Napthalene	9690	17442
Oil, Cotton Seed	9500	17100
Fuel	10300–10700	18500–19300
Olive	9476	17051
Rape	9489	17081
Sperm	10000	18000
Paraffin	11140	20050
Peat	5940	10692
Petroleum, Liquid	10000–12000	18000–21600
Pitch	8400	15120
Starch	4228	7610
Sugar Cane	3961	7130
Sulphur	2221	3998
Tallow	9500	17100
Wood, Hard	4750	8550
Soft resinous	5050	9090

1.8 × Calories per gram = B. T. Us. per pound.
0.555 × B. T. Us. per pound = Calories per gram.

TYCOS MINERAL OIL TABLES

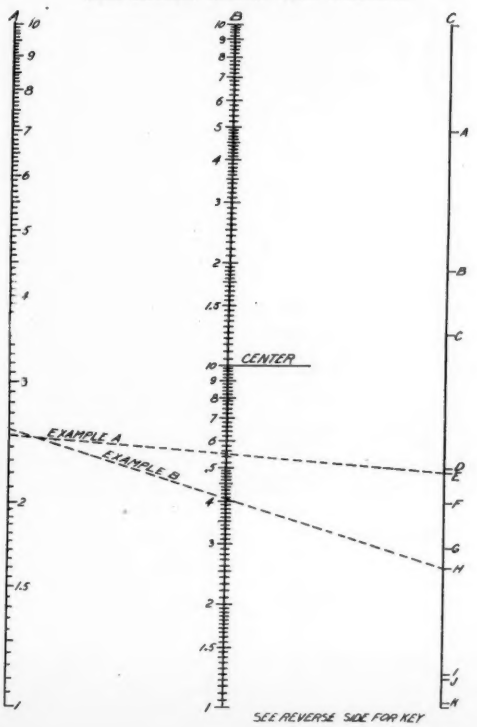
POWER PLANT ENGINEERING

CHART FOR DETERMINING SHEAR AREA OF KEY



POWER PLANT ENGINEERING

CONVERSION CHART FOR WEIGHTS



POWER PLANT ENGINEERING

CONVERSION CHART FOR LINEAR MEASUREMENTS

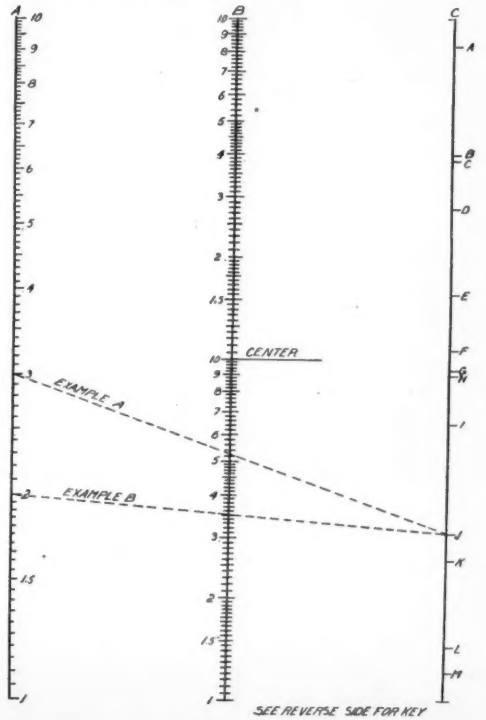
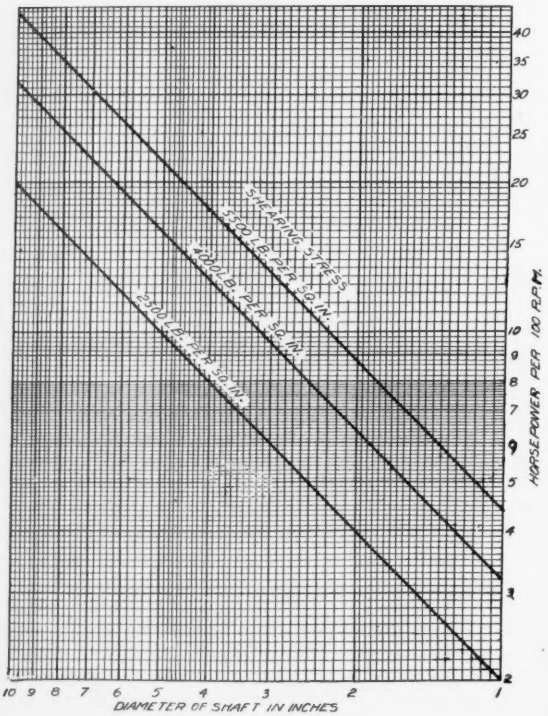


CHART SHOWING HORSEPOWER PER 100 R. P. M. TRANSMITTED BY ONE SQUARE INCH OF KEY AREA



Interesting Temperatures

	Deg. F.	Deg. C.
Absolute Zero	—459.4	—273.
Liquid Air	—297.4	—183.
Alcohol Freezes	—179.68	—117.6
Mercury Freezes	— 37.97	— 38.87*
Ammonia Boils	— 37.3	— 38.5
Water Freezes	+ 32.	0. *
Alcohol Boils	173.12	78.4
Water Boils	212.	100. *
Tin melts	449.4	231.9 *
Lead melts	621.3	327.4 *
Mercury Boils	675.05	357.25
Zinc Melts	786.9	419.4 *
Sulphur Boils	832.3	444.6 *
Antimony Melts	1166.	630. *
Aluminum Melts	1217.7	658.7 *
Salt (NaCl) Solidifies	1473.8	801. *
Silver Melts	1761.	960.5 *
Gold Melts	1945.5	1063. *
Copper Melts	1981.5	1083. *
Nickel Melts	2646.	1452. *
Iron Melts	2786.	1530. *
Platinum Melts	3191.	1755. *
Tungsten Melts	5430.	3000. *
Carbon Melts about	6500.	3600. *

Barometric Pressure 760 mm.

*Bureau of Standards Circular No. 35, Second Edition.

TYCOS MINERAL OIL TABLES

KEY TO CONVERSION CHART FOR LINEAR MEASUREMENTS

Scale A	Scale B	Scale C	To Locate Decimal*	
			Below Center	Above Center
Centimeters	Inches	E	−1	0
Centimeters	Feet	F	−2	−1
Centimeters	Yards	M	−2	−1
Centimeters	Miles	C	−6	−5
Inches	Meters	I	−2	−1
Feet	Inches	L	+1	+2
Feet	Meters	G	−1	0
Yards	Feet	H	0	+1
Yards	Meters	A	−1	0
Miles	Inches	B	+4	+5
Miles	Feet	D	+3	+4
Miles	Yards	J	+3	+4
Miles	Meters	K	+3	+4

*The number of digits to the left of the decimal point in scale B is more or less than that in scale A by the amount shown in these two columns. The scales are read similarly to those on a slide rule, i.e., the numbered divisions represent the first significant figure, the intermediate unnumbered divisions represent the second figure, and the third figure must be interpolated.

Examples: (A) The number of yards in 3 miles is 5280.
(B) The number of miles in 3460 yards is 2.

KEY TO CONVERSION CHART FOR WEIGHTS

Scale A	Scale B	Scale C	To Locate Decimals*	
			Below Center	Above Center
Kilograms	Grains	G	+4	+5
Kilograms	Ounces, Avoir.	C	+1	+2
Kilograms	Pounds	E	0	+1
Ounces, Avoir.	Grains	B	+2	+3
Pounds, Avoir.	Ounces, Avoir.	H	+1	+2
Pounds, Avoir.	Grains	A	+3	+4
Short Tons	Pounds, Avoir.	F	+3	+4
Long Tons	Pounds, Avoir.	D	+3	+4
Metric Tons	Pounds, Avoir.	E	+3	+4
Long Tons	Short Tons	I	0	+1
Long Tons	Metric Tons	K	0	+1
Metric Tons	Short Tons	J	0	+1

*The number of digits to the left of the decimal point in scale B is more or less than that in scale A by the amount shown in these two columns. The scales are read similarly to those on a slide rule, i.e., the numbered divisions represent the first significant figure, the intermediate unnumbered divisions represent the second figure, and the third figure must be interpolated.

Examples: (A) The number of pounds in 25 kilograms is 551.
(B) The number of pounds in 408 ounces avoirdupois is 25.5.